I/O Expansion

Serial Bases:

IOE-4404
IOE-4422
IOE-4440

Expansion Modules:

IOEX-4404
IOEX-4422
IOEX-4440

Covering Firmware 2.2.0

User Manual and Reference Guide

Part Number: LUM0017AB
Revision: A
Last Updated: 01/23/2012

Safety Information

The products described in this manual can fail in a variety of modes due to misuse, age, or malfunction. Systems with these products must be designed to prevent personal injury and property damage during product operation and in the event of product failure.

Warning! ***Do not*** remove or insert diagnostics cable while circuit is live unless the area is known to be free of ignition concentrations of flammable gases or vapors.

Warranty

FreeWave Technologies, Inc. warrants your FreeWave® Wireless Data Transceiver against defects in materials and manufacturing for a period of two years from the date of shipment. In the event of a Product failure due to materials or workmanship, FreeWave will, at its option, repair or replace the Product. The Product must be returned to FreeWave upon receiving a Return Material Authorization (RMA) for evaluation of Warranty Coverage.

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2. If Product is used outside of FreeWave specifications.
3. If Product has been modified, repaired, or altered by Customer unless FreeWave specifically authorized such alterations in each instance in writing. This includes the addition of conformal coating.

Special Rate Replacement Option

A special rate replacement option is offered to non-warranty returns or upgrades. The option to purchase the replacement unit at this special rate is only valid for that RMA. The special replacement rate option expires if not exercised within 30 days of final disposition of RMA.

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FreeWave Technologies, Inc.
1800 South Flatiron Court
Boulder, CO 80301
303.381.9200
Toll Free: 1.866.923.6168
Fax: 303.786.9948
www.freewave.com

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UL Notifications

Models IOE-4404, IOE-4422, IOE-4440, IOEX-4404, IOEX-4422, and IOEX-4440 are suitable for use in Class1, Division 2, Groups A, B, C, and D or non-hazardous locations only.

The connectors shall not be connected or disconnected while circuit is live unless area is known to be non-hazardous.

Warning! Explosion Hazard - Substitution of any component may impair suitability for Class 1, Division 2.

Warning! Do not remove or insert the diagnostics cable while the circuit is live unless the area is known to be free of ignition concentrations or flammable gases and vaports.

Input voltage for the IOE and IOEX models is +7.5 to +30 VDC.

Subject Devices are to be installed in the vertical orientation only. Devices were tested for vertical orientation only and not the horizontal orientation.

Important: Input power and all I/O power, except relay output contacts, shall be derived from a single Class 2 power source, or equivalent.

FCC Notifications

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) this device must accept any interference received, including interference that may cause undesired operation.

This device must be operated as supplied by FreeWave Technologies, Inc.. Any changes or modifications made to the device without the express written approval of FreeWave Technologies, Inc. may void the user's authority to operate the device.

> **Note:** Whenever any FCC approved FreeWave Technologies, Inc. module is placed inside an enclosure a label **must** be placed on the outside of that enclosure which includes the module's FCC ID.

IC Notifications

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Ce dispositif est conforme aux normes permis-exemptes du Canada RSS d'industrie. L'opération est sujette aux deux conditions suivantes : (1) ce dispositif peut ne pas causer l'interférence, et (2) ce dispositif doit accepter n'importe quelle interférence, y compris l'interférence qui peut causer le fonctionnement peu désiré du dispositif.

Document Revision History

Date	Rev Letter	Updates Made
01/23/2012	A	Updated content to reflect firmware version 2.2.0: • The **40000 to 40003: AO Command** register description on page 54 has been updated to reflect the maximum output cap of 22 mA. • The firmware appendix beginning on page 65 has been updated to reflect 2.2.0 changes. The organization and layout of the manual have been updated: • Added a Preface which includes general information about this manual's contents, notational conventions used throughout, how to contact FreeWave Technical Support, and how to send feedback to FreeWave about this document. • Added information about Serial Base and Expansion Module LEDs. See "I/O Device LEDs" on page 5. • Updated channel descriptions to include detail about applicable Tool Suite fields and register settings that apply to each. See Chapter 2: "Channel Functions and Specifications." • Added a Glossary that begins on page 67.

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Preface

This document includes the following regarding the FreeWave I/O Expansion products:

- A basic introduction to the Serial Bases and Expansion Modules that make up the I/O product line.
- Descriptions of each port and LED on Serial Bases and Expansion Modules.
- A description of the parameters required for each channel.
- Steps to setting up and programming a stack of Expansion Modules using Tool Suite.
- Pin out and mechanical drawings.
- Modbus register map details.

For information about the firmware releases that apply to the I/O Expansion products, see Appendix A.

Notational Conventions

This guide uses the following notational conventions:

- **Bold** - Indicates items that you select, parameter settings, and parameter names.
- **Warning!** - Indicates a situation that might cause damage to your radio, data, or network.
- Tip - Provides time saving or informative suggestions about using the product.

The term "radio" and "transceiver" are used throughout this manual to refer to the described devices.

Contacting FreeWave Technical Support

For up-to-date troubleshooting information, check the Support page at www.freewave.com.

FreeWave provides technical support Monday through Friday, 7:30 AM to 5:30 PM Mountain Time (GMT -7). Call toll-free at 1.866.923.6168, within Colorado call 303.381.9200, or contact us through email at moreinfo@freewave.com.

Documentation Feedback

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Chapter 1: Introduction

The I/O Expansion product family provides expandable digital input, digital output, analog input, and analog output capabilities for any device with a Modbus controller. Expandable I/O can be added directly to PLCs, RTUs, and SCADA hosts. I/O Expansion can also integrate into new and existing wireless communication systems such as proprietary, licensed and unlicensed, cellular and satellite radio systems.

The I/O Expansion Module may either be stacked on an applicable I/O base or can serve as expandable I/O modules through a serial connection. Regardless of the configuration, up to 15 modules can be stacked on a single Radio Base or Serial Base, providing up to 192 I/O points, including those on the Base Module.

About Base Modules and Expansion Modules

The bottom unit in a stack of I/O Expansion Modules is referred to as the Base Module and provides communication to the outside world. The Base Module in a stack can be one of the following:

- **Radio Base** - A Radio Base provides expandable, *wireless* I/O and can be polled and controlled wirelessly across FreeWave's wireless serial network. The FGR2-IO-IOE radio is the only Radio Base device available. The photo of an I/O Expansion stack on previous page shows an FGR2-IO-IOE as the Base Module. For information about the FGR2-IO-IOE, see the *Wire Replacement I/O User Manual* (part number LUM0008AC) This document does not provide reference information for the FGR2-IO-IOE.
- **Serial Base** - A Serial Base provides expandable, *wired* I/O to any device with RS232, RS422, and RS484 data communication interfaces. Serial Bases come in the following models:
  - IOE-4404
  - IOE-4422
  - IOE-4440

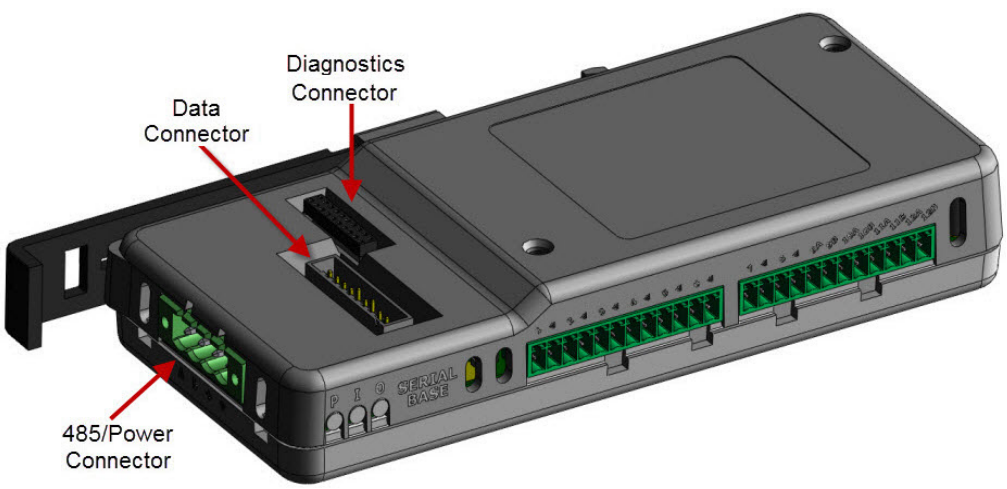
Expansion Modules can be added to a Radio Base or Serial Base device to expand the number of I/O channels available. Expansion Modules on their own do not communicate. They must be connected to a Radio Base or a Serial Base. The following expansion modules are available. The "X" in the model number indicates that the model is an expansion module.

- IOEX-4404
- IOEX-4422
- IOEX-4440

Different isolated channels are available depending on the model number. For more information, see "Channel Functions and Specifications" on page 9.

Serial Base Connectors

The following sections describe each connector on a Serial Base and the pin layout of each. For information about the I/O channels available on the Serial Base, see "Channel Functions and Specifications" on page 9.



Serial Base Data Connector

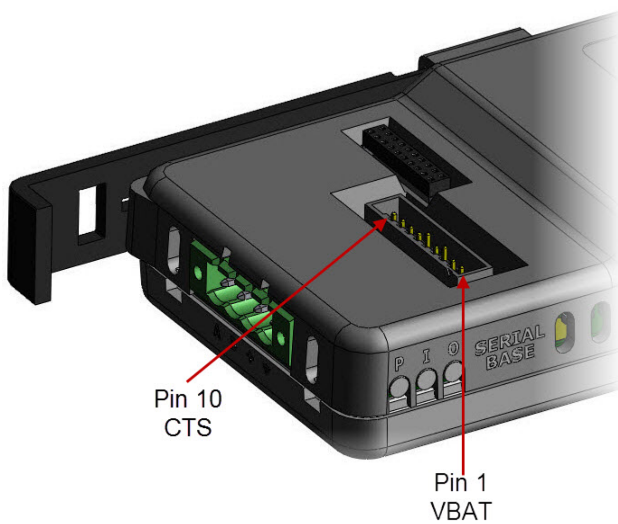
This 10-pin connector provides serial communication and power to the Serial Base and supports RS232, RS422, and RS485 serial communication interfaces.

When Expansion Modules are connected to the Serial Base, power is provided to the Expansion Modules through the power and ground pins on this connector. If the Expansion Modules have a Serial Base, power can alternatively be supplied by the serial 485/Power Connector described in "Serial Base 485/Power Connector" on page 3.

The following pin-out summarizes the function of each pin in the 10-pin data connector:

1.	VBAT	Power
2.	Interrupt	Interrupt used to place the Base into Setup Mode
3.	DTR	Data Terminal Ready
4.	Ground	Ground
5.	TXD	Transmit Data
6.	Ground	Ground
7.	RXD	Receive Data
8.	DCD	Carrier Detect
9.	RTS	Request to Send
10.	CTS	Clear to Send

Pin 1 is the closest pin to the edge of device:



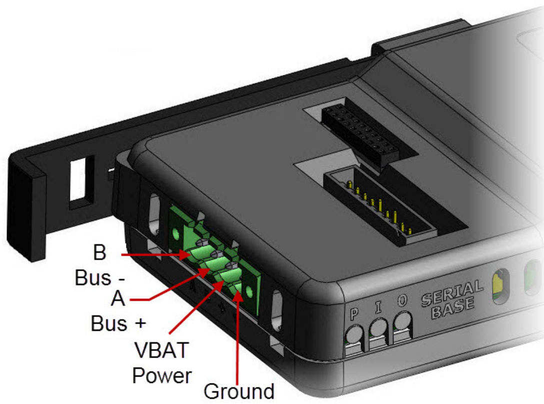
Serial Base 485/Power Connector

This 4-pin connector provides serial communication and power to the Serial Base and any attached Expansion Modules. The serial communication interface is limited to two-wire 485 when a shorting connector is placed on the 10-pin connector on top of the device. The shorting connector shorts pins 5 (TXD) to 7 (RXD) for Bus + and pins 9 (RTS) and 10 (CTS) for Bus -.

The following pin-out summarizes the function of each pin:

B	Bus – for two-wire 485 half duplex with shorting connector
A	Bus + for two-wire 485 half duplex with shorting connector
VBAT	Power
Ground	Ground

The pins are in the following orientation:



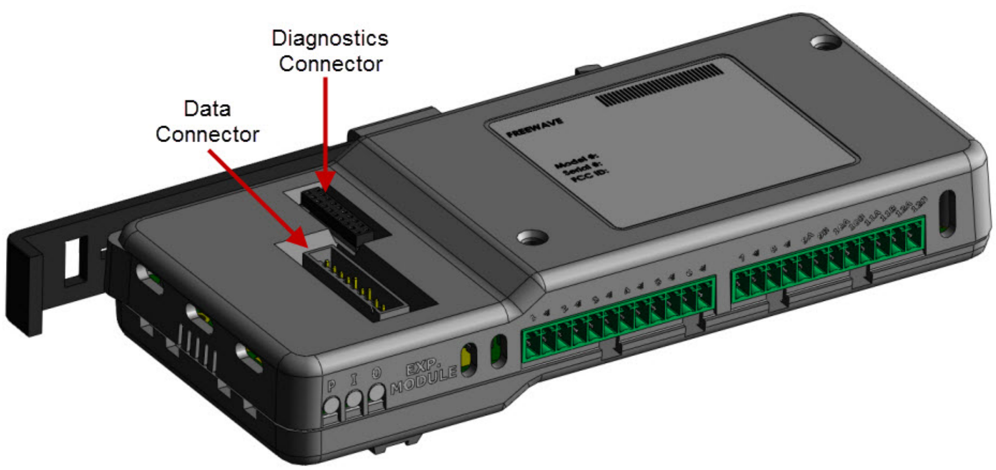
Serial Base Diagnostics Connector

This 20-pin connector provides configuration access to the Serial Base with the Tool Suite configuration software without removing either the Data Connector or 485/Power connector.

The 20-pin connector on an attached Expansion Module passes diagnostic data and settings directly to and from the base module (Serial Base or Radio Base).

Expansion Module Connectors

The following sections describe each connector on an I/O Expansion Module. For information about the I/O channels available on the Expansion Modules, see "Channel Functions and Specifications" on page 9.



Expansion Module Data Connector

The 10-pin data connector passes data directly through to the Serial Base or Radio Base. For more information, see "Serial Base Data Connector" on page 2 or the documentation for the Radio Base for detailed descriptions.

The data connector on the top Expansion Module can be used to provide power to all devices in the stack. Connecting power to the 10-pin data connector on the top module delivers the supply voltage to all modules in the stack. The following pin-out summarizes the function of each pin:

1.	VBAT	Power
2.	Interrupt	Interrupt used to place the Base into Setup Mode
3.	DTR	Data Terminal Ready input of Serial Base
4.	Ground	Ground
5.	TXD	Transmit data output of the Serial Base or Radio Base. Y+ data of RS485 output.
6.	Ground	Ground
7.	RXD	Receive data input of the Serial Base or Radio Base. A+ data of RS485 input.
8.	DCD	Carrier Detect output of Radio Base
9.	RTS	B- data of RS485 input
10.	CTS	Z- data of RS485 input

Expansion Module Diagnostics Connector

The 20-pin diagnostic connector provides board-to-board communication for stacked Expansion Modules. It also provides access to the diagnostic connector on the base device, whether a Serial Base or Radio Base.

I/O Device LEDs

The LEDs on the Serial Base and Expansion Modules in a stack help identify the state of the system and the current action happening with each device in the stack:

- **Power** - Labeled with a P in enclosed Serial Bases and Expansion Modules, this is the LED closest to the edge of the device.
- **Inbound** - Labeled with an I in enclosed Serial Bases and Expansion Modules, this is the middle LED.
- **Outbound** - Labeled with an O in enclosed Serial Bases and Expansion Modules, this is the LED closest to the I/O channels.

The LEDs are either red or green, solid, flashing intermittently, or blinking. The state of each LED is described in the sections below.

Warning! If all the LEDs are solid red or blinking red the device is receiving a firmware upgrade. Do not unplug the device or remove the device's power during a firmware upgrade. The device could become inoperable.

Serial Base LEDs

	Serial Base Module		
LED State	Power (P)	Inbound (I)	Outbound (O)
Solid green	Power on	-	-
Intermittent green flash	Low power mode	Receiving a message from the rest of the stack	Device is sending data after being polled
Blinking green	Communication reset mode, device is gathering startup settings	-	Device is sending data when polled
Solid red	Firmware upgrade initiated*	1) When the other LEDs are also solid red a firmware upgrade has been initiated	1) When the other LEDs are also solid red a firmware upgrade has been initiated
Intermittent red flash	-	1) If other LEDs are also intermittently flashing red, internal checks after firmware upgrade 2) Device is being polled	If other LEDs are also intermittently flashing red, internal checks after firmware upgrade
Blinking red	Internal checks after firmware upgrade	Internal checks after firmware upgrade	Sending information to devices in the stack

* The Incoming and Outgoing LEDs may appear to blink depending on how many registers are read during a single polling cycle.

Expansion Module LEDs

	Expansion Module		
LED State	Power (P)	Inbound (I)	Outbound (O)
Solid green	Power on	-	-
Intermittent green flash	Low power mode	-	Sending information down the stack to the base
Blinking green *	Communication reset mode, device is gathering startup settings	-	-
Solid red	Firmware upgrade initiated*	1) When the other LEDs are also solid red a firmware upgrade has been initiated 2) Receiving a command from the base	1) When the other LEDs are also solid red a firmware upgrade has been initiated 2) Receiving a command from the base
Intermittent red flash	-	Device is being polled	-
Blinking red *	Internal checks after firmware upgrade	Internal checks after firmware upgrade	Sending information to devices in the stack

* The Incoming and Outgoing LEDs may appear to blink depending on how many registers are read during a single polling cycle.

Powering Serial Bases and Expansion Modules

Power is shared between all devices in a stack of Expansion Modules. When one device in the stack is powered (Expansion Module, Serial Base, or Radio Base) then all connected devices are powered.

A stack of Expansion Modules can be powered through one of the following:

- Data Connector on the top Expansion Module. See "Expansion Module Data Connector" on page 5.
- 485/Power Connector on a Serial Base. See "Serial Base 485/Power Connector" on page 3.
- I/O Connector on a Radio Base. See the *Wire Replacement I/O User Manual* (part number LUM0008AC) for details about powering the FGR2-IO-IOE.

Power supply voltage limits for all Serial Base and Expansion Modules are as follows:

Item	Min	Typical	Max	Units
Power Supply Voltage	7.5	-	30	V

The following table provides the current consumption for a sample Serial Base and Expansion Module configuration as follows:

Channel Configuration			Current Consumption at 12 V (in mA)
Universal Channels	**Input-Only Channels**	**Isolated Channels**	**12 V**
Disabled	Disabled	Disabled	**17.0**
DO: Off	Disabled	DO: Off	**17.0**
DO: On	Disabled	DO: On	**18.1**
DI	DI	DI	**17.0**
AO: 0 mA	Disabled	Disabled	**18.2**
AO: 20 mA	Disabled	Disabled	**98.2**
AI: Voltage	AI: Voltage	Disabled	**17.0**
AI: Current	AI:Current	Disabled	**25.0**

Chapter 2: Channel Functions and Specifications

All I/O Expansion devices have 12 I/O channels. All models feature four universally configurable channels, four input-only channels, and four electrically isolated channels.

The different models have the following I/O configuration:

- IOE-4440 and IOEX-4440 - All four isolated channels are digital inputs.
- IOE-4422 and IOEX-4422 - Two isolated channels are digital inputs and two isolated channels are digital outputs.
- IOE-4404 and IOEX-4404 - All four isolated channels are digital outputs.

IOE-4440 and IOEX-4440 Channels

The following channels are available on the IOE-4440 and IOEX-4400 Channels. Any channel column with a dot (•) in the table below is available in this model.

		Universal Channels				Input-Only Channels				Isolated Channels			
4440 Channels	**Number**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Digital Input	12	•	•	•	•	•	•	•	•	•	•	•	•
Digital Output	4	•	•	•	•								
Analog Input	8	•	•	•	•	•	•	•	•				
Analog Output	4	•	•	•	•								
Sensor Power	4	•	•	•	•								

IOE-4422 and IOEX-4422 Channels

The following channels are available on the IOE-4422 and IOEX-4422 Channels. Any channel column with a dot (•) in the table below is available in this model.

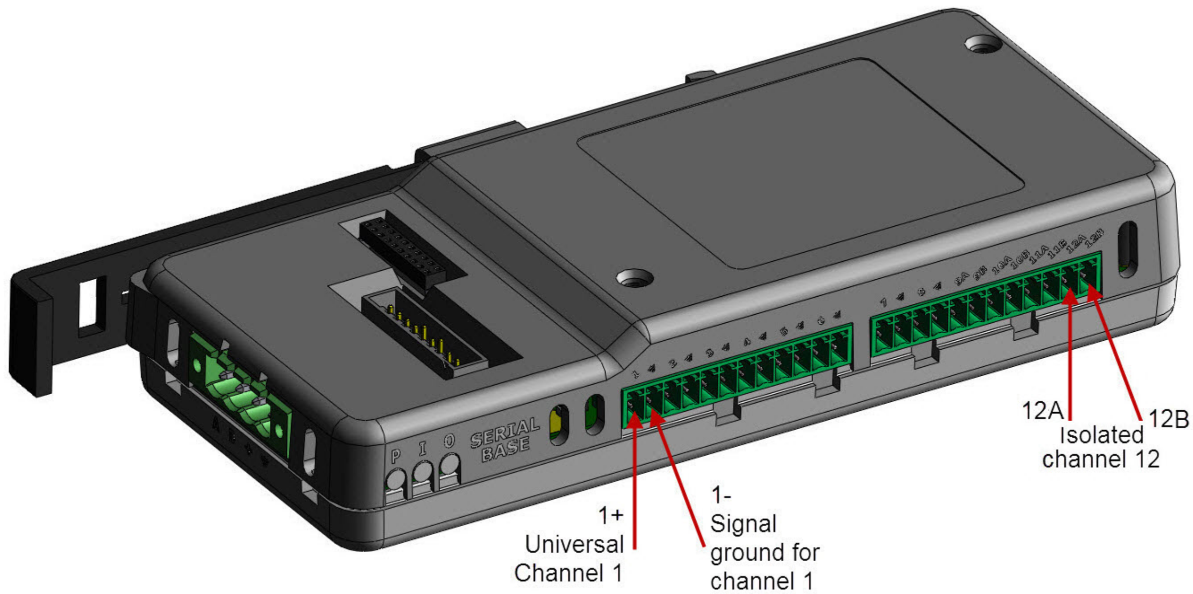
		Universal Channels				Input-Only Channels				Isolated Channels			
4422 Channels	**Number**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Digital Input	10	•	•	•	•	•	•	•	•	•	•		
Digital Output	6	•	•	•	•							•	•
Analog Input	8	•	•	•	•	•	•	•	•				
Analog Output	4	•	•	•	•								
Sensor Power	4	•	•	•	•								

IOE-4404 and IOEX-4404 Channels

The following channels are available on the IOE-4404 and IOEX-4404 Channels. Any channel column with a dot (•) in the table below is available in this model.

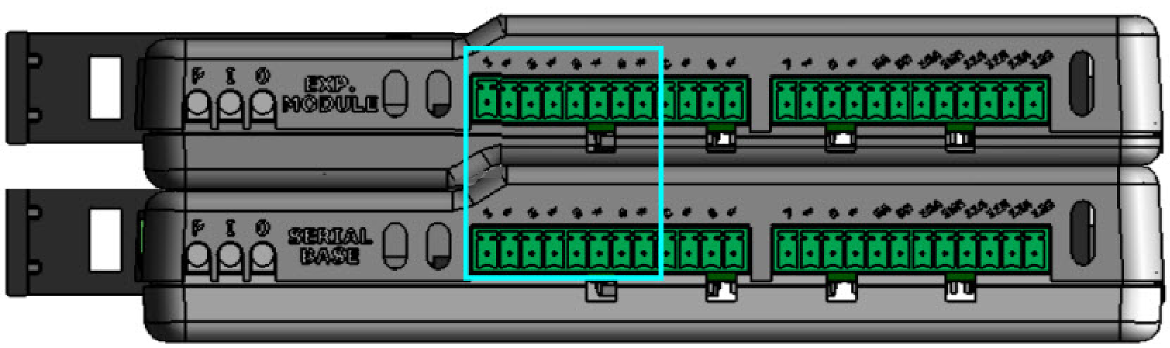
		Universal Channels				Input-Only Channels				Isolated Channels			
4404 Channels	**Number**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Digital Input	8	•	•	•	•	•	•	•	•				
Digital Output	8	•	•	•	•					•	•	•	•
Analog Input	8	•	•	•	•	•	•	•	•				
Analog Output	4	•	•	•	•								
Sensor Power	4	•	•	•	•								

The I/O channels are numbered left to right and each as a channel port and a signal ground port:



Universal Channels

Channels 1, 2, 3, and 4 on all Serial Base and Expansion Modules are universal channels. Universal channels can be configured as Digital Input, Digital Output, Analog Input, Analog Output, or Sensor Power channels.



The following sections describe the features and characteristics of each universal channel configuration.

Universal Channel as Digital Input

A universal Digital Input provides data to the following registers:

- **10000 to 10011: DI State** - The present state of the channel.
- **30064 to 30087: DI Counter** - The number of pulse edges seen on the channel.

You can configure a Digital Input's settings in either Tool Suite or directly through the register settings. For information about setting a universal channel as a Digital Input, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure a Digital Input.

Field in Tool Suite	Register	Description
Counter Edge	**96 to 106: DI Counter Falling Edge Increment**	Sets the pulse edge on which the **DI Counter** register increments. Select **Falling Edge**to increment the **DI Counter** register when the input goes from 1 to 0. In the Modbus register, this is **(1) ON**. Select **Rising Edge** to increment the **DI Counter** register when input goes from 0 to 1. In the Modbus register, this is **(0) OFF**.
Resistor Pull	**40056 to 40063: Resistor Pull Setting**	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.

Set additional functionality for a Digital Input using the following registers that do not have an equivalent field in Tool Suite:

Register	Description
72 to 83: DI Counter Clear	Clears the Digital Input counter to 0. Critical counting ensures that each pulse is reported by only clearing pulses that you have read. For more information, see the **DI Counter Clear** register description on page 51.
136 to 147: DI Counter Latch	Allows you to scan for the input change at a much slower speed than the duration of the pulse. For more information, see the **DI Counter Latch** register description on page 52.
152 to 163: Pulse Counter De-bounce	Enables the system to take multiple samples before determining that an edge is real and not noise on the channel. Universal Digital Inputs support pulse counting for input signals up to 100 Hz; de-bounced pulse counting for input signals to 10 Hz.

A universal channel configured as a Digital Input has the following specifications:

Item	Min	Typical	Max	Units
Input Low (OFF) voltage	0	-	2.5	V
Input High (ON) voltage	3.0	-	Actual Power Supply Voltage	V
Pulse counting frequency	-	-	100	Hz
De-bounced pulse counting frequency	-	-	10	Hz
Pulse width	4	-	-	ms
De-bounced pulse width	40	-	-	ms
Pull-up resistance	-	1	-	kΩ
Pull-up voltage (measured externally)	-	3.0	-	V
Pull-down resistance to ground	-	10	-	kΩ

Universal Channel as Digital Output

A universal channel configured as a Digital Output has the following characteristics:

- Solid-state digital outputs with reverse-blocking Schottky diodes are rated at 1 A across the complete operating temperature range.
- Output voltage range up to 30 V, or device supply voltage, whichever is less.
- Circuitry protection. If an overload occurs, the channel turns off automatically. For more information, see the description for **10024 to 10035: Circuitry Protection Active** register on page 52.
- Each channel has a ground pin for current return that must be used for large currents (over 0.1 A).
- Reports approximate amount of current flowing to ground.
- Configurable for normally open or normally closed.

A Digital Output reports its current in milliAmps to the **30112 to 30119: DO Current** register.

You can configure a Digital Output's settings in either Tool Suite or directly through the register settings. For information about setting a universal channel as Digital Output, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure a Digital Output.

Field in Tool Suite	Register	Description
Apply Default Output	**24 to 35: Apply Default DO, AO, Sensor Power**	If set to **Yes**, when a device powers up or a communication timeout has occurred, the channel uses the values set in the **Default DO, Sensor Power State** register. In the Modbus register, this is (1) ON. If set to **Yes**, also set the **Default Output** field or the **Default DO, Sensor Power State** register. If set to **No**, when a device powers up or a communication timeout has occurred, the channel remains off. In the Modbus register, this is (0) OFF.
Default Output	**48 to 59: Default DO, Sensor Power State**	If you selected to apply defaults on power up or after a communication timeout, use this setting to set the default state of the channel.
Monostable Time	**40080 to 40091: DO Monostable Timeout**	Enter the amount of time in milliseconds from 1 to 60000 (1 minute) after which the Digital Output channel goes to the state defined in the **Default DO, Sensor Power State** register. When set to 0 milliseconds, the channel is bi-stable and maintains its most recent state until it receives a command to change its state.

Set the following field in the Stack Settings tab in Tool Suite for the Serial Base in the stack:

Field	Description
Default Delay	Enter the amount of time in seconds that an Expansion Module or Serial Base waits for a Modbus command or query before a communication timeout occurs. When a communication timeout occurs, the action defined in the **Apply Default DO, AO, Sensor Power** is taken. For more information, see the register description on page 50.

Set additional functionality for a Digital Output using the following registers that do not have an equivalent field in Tool Suite:

Register	Description
0 to 11: DO, Sensor Power On	Set to (1) ON to sink current to ground when the transistor powers up. When set to (0) OFF, the transistor turns off and the output remains floating, unless the **Resistor Pull Setting** register is set to 1 or 2.

Register	Description
40056 to 40063: Resistor Pull Setting	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.

A universal channel configured as a Digital Output has the following specifications:

Item	Min	Typical	Max	Units
Output ON sinking current	-	-	1	A
Output ON resistance to ground*	0	0.1	0.2	Ω
Output ON circuitry protection limit	-	1.25	-	A
Output OFF resistance to ground	234	-	-	kΩ
External load voltage connection	0	-	V_{BAT}	V
Pull-up resistance	-	1	-	kΩ
Pull-up voltage (measured externally)	-	3.0	-	V
Pull-down resistance to ground	-	10	-	kΩ

* Dynamic resistance; a reverse-blocking Shottky diode is in series.

Universal Channel as Analog Input

A universal channel configured as an Analog Input returns data to the **30000 to 30016: AI Integer Result** register and **30032 to 30047: AI Floating Point Result** register associated with the channel. The channel also has circuitry protection. If an overload occurs, the channel turns off automatically. For more information, see the description for **10024 to 10035: Circuitry Protection Active** register on page 52.

You can configure an Analog Input's settings in either Tool Suite or directly through the register settings.

For information about setting a universal channel as an Analog Input, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure an Analog Input.

Field in Tool Suite	Equivalent Register	Description
Voltage Or Current	**120 to 127: AI Current Mode**	Select **Voltage** to return information in Volts (V). In the Modbus register, this is (1) ON. Select **Current** to return current information in milliAmps (mA). In the Modbus register, this is (0) OFF. • 20-bit analog-to-digital converter yields 0.10% reading accuracy across entire operating temperature for voltage and current input signals. • Voltage range supports 1 to 5 V and 0 to 10 V analog signals. Complete voltage range is -2.5 to 12.5 V. • Current range supports 4 to 20 mA analog signals. Complete current range is 0 to 25 mA.
Offset/Zero	**40112 to 40119 AI, AO Zero Current** **40096 to 40103: AI Zero Voltage**	Calibrates the low end of the Analog Input to zero. Set between 0 to 10000 mV or mA depend-ing on your setting in the **Voltage Or Current** field.
Span	**40104 to 40111: AI Voltage Span** **40120 to 40127: 40 AI, AO Current Span**	Sets the high end, or range, of the Analog Input. See the **AI, AO Current Span** register description on page 54 for setting recommendations. For 16-bit readings, set between 0 and 65535. For 20-bit readings, set between 0 and 1,048,575.
Filtering/ Averaging	**40040 to 40027: AI Filter Setting**	Sets a moving average, in seconds, for the **AI Integer Result** and **AI Floating Point Result** registers. You can use this setting to help filter out signal noise if in a noisy environment. FreeWave recommends leaving this setting at **0**. Select from the following settings: • 0 - Disabled • 1 - 10 seconds (0.1 Hz) • 2 - 25 seconds (0.04 Hz) • 3 - 50 seconds (0.02 Hz) • 4 - 100 seconds (0.01 Hz) • 5 - 250 seconds (0.004 Hz)

Field in Tool Suite	Equivalent Register	Description
Resistor Pull	**40056 to 40063: Resistor Pull Setting**	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.
Integer Type	**112 to 119: AI Signed Integer Result**	Sets the integer type to a signed or unsigned integer in the **AI Integer Result** register. A signed integer is required to report negative input voltages or if the RTU/PLC supports signed integers only. Setting this register to 0 results in an unsigned integer returned in the AI Integer Result register. Setting to 1 results in a signed integer.

Set the following fields in the Stack Settings tab in Tool Suite for the Serial Base:

Field	Description
Floating Point Word Order	Determines the position of the Most Significant Word (MSW) and Lease Significant Word (LSW) in the **AI Floating Point Result** register for all devices in the stack. Regular word order places the MSW at the lower address and the LSW at the higher address. For example MSW = 30032, LSW = 30033. Inverted word order places the LSW at the lower address and the MSW at the higher address. For example LSW = 30032, MSW = 30033).
AI Integer Results Justification	Determines the alignment of the **AI Integer Result** register. Options include Left and Right.

A universal channel configured as an Analog Input has the following specifications:

Item	Min	Typical	Max	Units
Voltage Input				
Analog input voltage	-2.5	-	lesser of 30 V or V_{BAT}	V
Full-scale input voltage*	-	13.75	-	V
Resolution*	-	20	-	Bits
Scaling factor (all 20 bits)*	-	9.54	-	µV/LSB

Item	Min	Typical	Max	Units
Scaling factor (upper 16 bits)*	-	153	-	µV/LSB
Accuracy error (0 to 5 V input)	0	-	Greater of 1 mV or 0.10% of input	mA
Current Input				
Analog input current	0	-	25	mA
Circuitry protection limit	-	25	-	mA
Internal sense resistor	249	250	251	Ω
Full-scale input current range*	-	40	-	mA
Resolution	-	20	-	Bits
Scaling factor (all 20 bits)*	-	38.1	-	nA/LSB
Scaling factor (upper 16 bits)*	-	610	-	na/LSB
Accuracy error (4 to 20 mA input)	0	-	Greater of 4 µA or 0.10% of input	

*These settings apply only when zero and span registers are set to 0 (default)

Universal Channel as Analog Output

You can configure a Analog Output's settings in either Tool Suite or directly through the register settings. For information about setting a universal channel as an Analog Output, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure an Analog Output.

Field in Tool Suite	Register	Description
Scaling	**40072 to 40075: AO Resolution**	Sets the resolution of the **AO Command** register. Set to one of the following options: • microAmps (1 microAmp per bit) • 16-bit resolution • 15-bit resolution. This is the recommended setting PLCs or RTUs that only support 16-bit signed integers. • 14- bit resolution • 12-bit resolution Current range supports 4 to 20 mA analog signals. Complete current range is 0 to 25 mA.

Field in Tool Suite	Register	Description
Apply Default Output	**24 to 35: Apply Default DO, AO, Sensor Power**	If set to **Yes**, when a device powers up or a communication timeout has occurred, the channel uses the values set in the **AO Command** register. In the Modbus register, this is (1) ON. If set to **Yes**, also set the **Default Output** field or the **Default AO Command** register. If set to **No**, when a device powers up or a communication timeout has occurred, the factory defaults are applied to the channel. In the Modbus register, this is (0) OFF.
Default Output	**40008 to 40011: Default AO Command**	If you selected to apply defaults on power up or after a communication timeout, use this setting to set the default state of the channel.
Offset/Zero	**40112 to 40119: AI, AO Zero Current**	Calibrates the low end of the Analog Output to zero. Set between 0 to 10000 mV or mA depending on your setting in the **Voltage Or Current** field.
Span	**40112 to 40119: AI, AO Zero Current** **40120 to 40127: AI, AO Current Span**	Sets the high end, or range, of the Analog Output. See the **AI, AO Current Span** register description on page 56for setting recommendations. For 16-bit readings, set between 0 and 65535. For 20-bit readings, set between 0 and 1,048,575.
Resistor Pull	**40056 to 40063: Resistor Pull Setting**	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.

A universal channel configured as a Analog Output has the following specifications:

Item	Min	Typical	Max	Units
Analog output current	0	-	22	mA
Full-scale output current*	-	25	-	mA
Resolution	-	25	-	Bits
Scaling factor*	-	1	-	µA/LSB
Voltage on output pin	-	-	V_{BAT}-0.5	V

Item	Min	Typical	Max	Units
Accuracy error (at 20 mA output)	-0.25	-	0.25	%

* These settings apply only when the zero and range registers are set to 0 (default).

Universal Channel as Sensor Power

A universal channel configured as a Sensor Power channel provides the following:

- Power for sensors and transmitters up to 50 mA.
- Voltage provided to the transmitter is roughly equal to the power provided to the Serial Base or Expansion Module, minus approximately 0.5 V, minus load current, multiplied by 10 ohms.
- Circuitry protection. If an overload occurs, the channel turns off automatically. For more information, see the description for **10024 to 10035: Circuitry Protection Active** register on page 52.

You can configure a Sensor Power channel's settings in either Tool Suite or directly through the register settings. For information about setting a universal channel as a Sensor Power channel, see "Defining Channel Settings in Tool Suite " on page 34

Use the information in the following table to configure a Sensor Power channel.

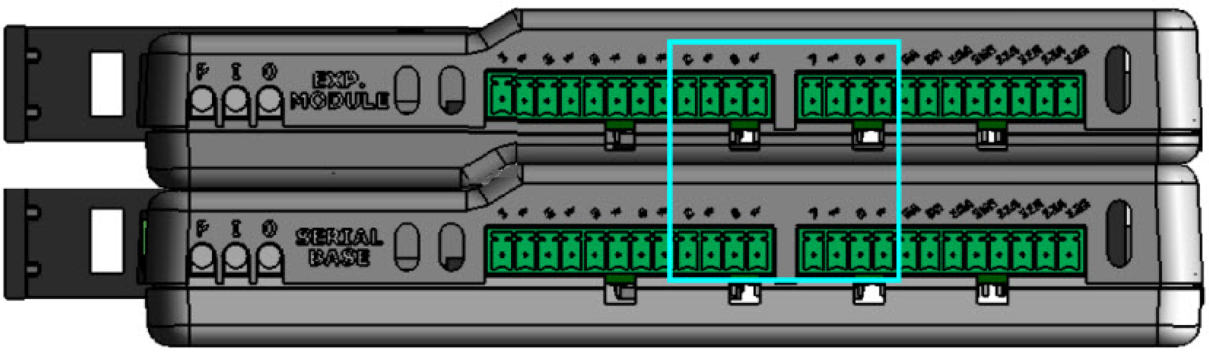
Field in Tool Suite	Register	Description
Apply Default Output	**24 to 35: Apply Default DO, AO, Sensor Power**	If set to **Yes**, when a device powers up or a communication timeout has occurred, the channel uses the values set in the **DO, Sensor Power On** register. In the Modbus register, this is (1) ON. If set to **Yes**, also set the **Default Output** field or the **Default DO, Sensor Power** register. If set to **No**, when a device powers up or a communication timeout has occurred, the factory defaults are applied to the channel. In the Modbus register, this is (0) OFF.
Default Output	**48 to 59: Default DO, Sensor Power State**	If you selected to apply defaults on power up or after a communication timeout, use this setting to set the default state of the channel.

A universal channel configured as Sensor Power has the following characteristics:

Item	Min	Typical	Max	Units
Voltage output	V_{BAT} - 1	V_{BAT} - 0.5	V_{BAT}	V
Current output	0	-	50	mA
Circuitry protection limit	-	52	-	mA

Input-Only Channels

Channels 5, 6, 7, and 8 on all Serial Bases and Expansion Modules are input-only channels. Input-only channels can be configured as Digital Input and Analog Input.



The following sections describe the features and characteristics of each input-only channel configuration.

Input-Only Channel as Digital Input

An input-only channel configured as a Digital Input provides data to the following registers:

- **10000 to 10011: DI State** - The present state of the channel.
- **30064 to 30087: DI Counter** - The number of pulse edges seen on the channel.

You can configure a Digital Input's settings in either Tool Suite or directly through the register settings. For information about setting an input-only channel as a Digital Input, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure an input-only channel Digital Input.

Field in Tool Suite	Register	Description
Counter Edge	**96 to 106: DI Counter Falling Edge Increment**	Sets the pulse edge on which the **DI Counter** register increments. Select **Falling Edge** to increment the **DI Counter** register when the input goes from 1 to 0. In the Modbus register, this is (1) ON. Select **Rising Edge** to increment the **DI Counter** register when input goes from 0 to 1. In the Modbus register, this is (0) OFF.

Field in Tool Suite	Register	Description
Counting Speed	**92 to 95: High-Speed DI Counter on Isolated**	Determines which channels use pulse counting for input signals up to 10 kHz. If you set an input-only channel to be high-speed, its corresponding isolated channel is set to standard speed. For more information, see the **High-Speed DI Counter on Isolated** register description on page 51 Select **Fast** to set the channel to high-speed. In the Modbus register, this is (1) ON.You can assign high-speed counting to only one channel of 5 or 9, 6 or 10, 7 or 11, and 8 or 12. **Note:** High-speed counting is not de-bounced and inputs must not go below GND. Select **Slow** to set the channel to standard-speed. Standard speed counters support 100 Hz pulses, or 10 Hz pulses with de-bounce. In the Modbus register, this is (0) OFF.
Resistor Pull	**40056 to 40063: Resistor Pull Setting**	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.

Important: For accurate counting at high speed, the voltage at the Digital Input pin must not drop below 0 V. Proper grounding techniques and short wiring connections are necessary to ensure accurate counting for high speed signals. If the voltage at the Digital Input pin drops below 0 V, there may be false edges detected and the Digital Input pulse count can be higher than expected.

Set additional functionality for a Digital Input using the following registers that do not have an equivalent field in Tool Suite:

Register	Description
72 to 83: DI Counter Clear	Clears the Digital Input counter to 0. Critical counting ensures that each pulse is reported by only clearing pulses that you have read. For more information, see the **DI Counter Clear** register description on page 51.

Register	Description
136 to 147: DI Counter Latch	Allows you to scan for the input change at a much slower speed than the duration of the pulse. For more information, see the **DI Counter Latch** register description on page 52.
152 to 163: Pulse Counter De-bounce	Enables the system to take multiple samples before determining that an edge is real and not noise on the channel. Digital Inputs support pulse counting for input signals up to 100 Hz; de-bounced pulse counting for input signals to 10 Hz. **Note:** High-speed counting is not de-bounced and inputs must not go below GND.

An input-only channel configured as a Digital Input has the following specifications:

Item	Min	Typical	Max	Units
Input low (OFF) voltage	0	-	2.5	V
Input high (ON) voltage	3.0	-	V_{DD}	V
Pulse counting frequency, standard speed	-	-	100	Hz
Pulse counting frequency, high speed	-	-	10	kHz
Pulse counting frequency, de-bounced pulse	-	-	10	Hz
Pulse width, standard speed	4	-	-	ms
Pulse width, high-speed	40	-	-	µs
Pulse width, de-bounced	40	-	-	ms
Pull-up resistance	-	1	-	kΩ
Pull-up voltage (measured externally)	-	3.0	-	V
Pull-down resistance to ground	-	10	-	kΩ

Input-Only Channel as Analog Input

An input-only channel configured as an Analog Input returns data to the **3000 to 30016: AI Integer Result** register and **30032 to 30047: AI Floating Point Result** register associated with the channel. The channel also has circuitry protection. If an overload occurs, the channel turns off automatically. For more information, see the description for **10024 to 10035: Circuitry Protection Active** register on page 52.

You can configure an Analog Input's settings in either Tool Suite or directly through the register settings. For information about setting an input-only channel as an Analog Input, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure an Analog Input.

Field in Tool Suite	Equivalent Register	Description
Voltage Or Current	**120 to 127: AI Current Mode**	Select **Voltage** to return information in Volts (V). In the Modbus register, this is (1) ON. Select **Current** to return current information in milliAmps (mA). In the Modbus register, this is (0) OFF. • 20-bit analog-to-digital converter yields 0.10% reading accuracy across entire operating temperature for voltage and current input signals. • Voltage range supports 1 to 5 V and 0 to 10 V analog signals. Complete voltage range is -2.5 to 12.5 V. • Current range supports 4 to 20 mA analog signals. Complete current range is 0 to 25 mA.
Offset/Zero	**40112 to 40119: AI, AO Zero Current** **40096 to 40103: AI Zero Voltage**	Calibrates the low end of the Analog Input to zero. Set between 0 to 10000 mV or mA depending on your setting in the **Voltage Or Current** field.
Span	**40104 to 40111: AI Voltage Span** **40120 to 40127: AI, AO Current Span**	Sets the high end, or range, of the Analog Input. See the **AI, AO Current Span** register description on page 56 for setting recommendations. For 16-bit readings, set between 0 and 65535. For 20-bit readings, set between 0 and 1,048,575.
Filtering/ Averaging	**40040 to 40047: AI Filter Setting**	Sets a moving average, in seconds, for the **AI Integer Result** and **AI Floating Point Result** registers. Use this setting to help filter out signal noise. Select from the following settings: • 0 - Disabled • 1 - 10 seconds • 2 - 25 seconds • 3 - 50 seconds • 4 - 100 seconds • 5 - 250 seconds

Field in Tool Suite	Equivalent Register	Description
Resistor Pull	**40056 to 40063: Resistor Pull Setting**	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.
Integer Type	**112 to 119: AI Signed Integer Result**	Sets the integer type to a signed or unsigned integer in the**AI Integer Result** register. A signed integer is required to report negative input voltages if the RTU/PLC supports signed integers only. Setting to **Signed** results in a signed integer. In the Modbus register, this is (1) ON. Setting to **Unsigned** results in an unsigned integer returned in the **AI Integer Result** register. In the Modbus register, this is (0) OFF.

Set the following parameters in the Stack Settings tab in Tool Suite for the Serial Base:

Field	Description
Floating Point Word Order	Determines the position of the Most Significant Word (MSW) and Lease Significant Word (LSW) in the **AI Floating Point Result** register for all devices in the stack. Regular word order places the MSW at the lower address and the LSW at the higher address. For example MSW = 30032, LSW = 30033. Inverted word order places the LSW at the lower address and the MSW at the higher address. For example LSW = 30032, MSW = 30033).
AI Integer Results Justification	Determines the alignment of the **AI Integer Result** register. Options include Left and Right.

An input-only channel configured as a Analog Input has the following specifications:

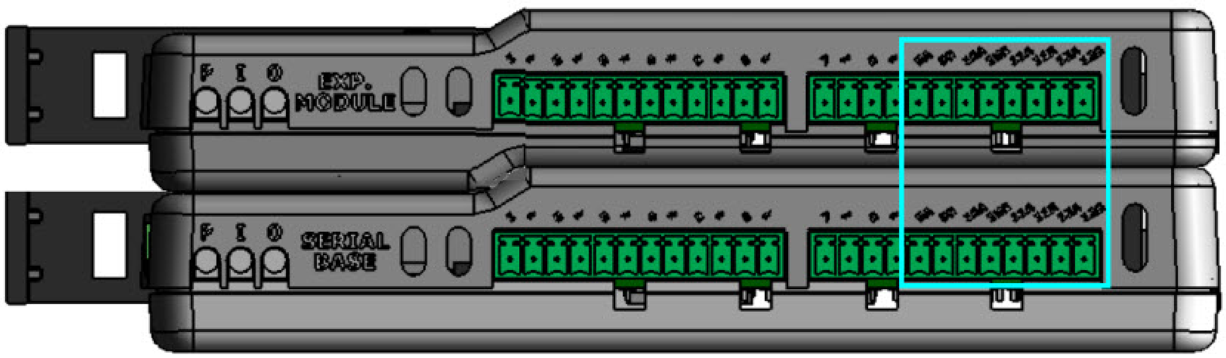
Item	Min	Typical	Max	Units
Voltage Input				
Analog input voltage	-2.5	-	30	V

Item	Min	Typical	Max	Units
Full-scale input voltage*	-	13.75	-	V
Resolution	-	20	-	Bits
Scaling factor (all 20 bits)*	-	9.54	-	µV/LSB
Scaling factor (upper 16 bits)*	-	153	-	µV/LSB
Accuracy error (0 to 5 V input)	0	-	Greater of 1 mV or 0.10% of input	mA
Current Input				
Analog input current	0	-	25	mA
Circuitry protection limit	-	25	-	mA
Internal sense resistor	249	250	251	Ω
Full-scale input current range*	-	40	-	mA
Resolution	-	20	-	Bits
Scaling factor (all 20 bits)*	-	38.1	-	nA/LSB
Scaling factor (upper 16 bits)*	-	610	-	nA/LSB
Accuracy error (4 to 20 mA input)	0	-	Greater of 4 µA or 0.10% of input	

*These settings apply only when zero and span registers are set to 0 (default)

Isolated Channels

Channels 9, 10, 11, and 12 are built in the factory for either Digital Input or Digital Output. These channels can only serve the function for which they were built.



The following sections describe the features and characteristics of each isolated channel configuration.

Isolated Channel as Digital Output

An isolated Digital Output reports its current in milliAmps to the **DO Current** register and also has the following characteristics:

- Mechanical relays capable of switching up to 2 A at 250 VDC or VAC
- Long life relays with 80,000 cycles
- Configured for normally open
- Circuitry protection. If an overload occurs, the channel turns off automatically. For more information, see the description for **10024 to 10035: Circuitry Protection Active** register on page 52.

You can configure a Digital Output's settings in either Tool Suite or directly through the register settings.For information about setting an isolated channel as a Digital Output, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure a Digital Output.

Field in Tool Suite	Register	Description
Apply Default Output	**24 to 35: Apply Default DO, AO, Sensor Power**	If set to **Yes**, when a device powers up or a communication timeout has occurred, the channel uses the values set in the **Default DO, Sensor Power State** register. In the Modbus register, this is (1) ON. If set to **Yes**, also set the **Default Output** field or the **Default DO, Sensor Power State** register. If set to **No**, when a device powers up or a communication timeout has occurred, the factory defaults are applied to the channel. In the Modbus register, this is (0) OFF.
Default Output	**48 to 59: Default DO, Sensor Power State**	If you selected to apply defaults on power up or after a communication timeout, use this setting to set the default state of the channel. For more information, see the **Default DO, Sensor Power State** register description on page 50.
Monostable Time	**40080 to 40091: DO Monostable Timeout**	Enter the amount of time in milliseconds from 1 to 60000 (1 minute) after which the Digital Output channel goes to the state defined in the **Default DO, Sensor Power State** register. When set to 0 milliseconds, the channel is bi-stable and maintains its most recent state until it receives a command to change its state.

In addition, set the following fields in the Stack Settings tab in Tool Suite for the Serial Base in the stack:

Field	Description
Default Delay	Enter the amount of time in seconds that an Expansion Module or Serial Base waits for a Modbus command or query before a communication timeout occurs.

Set the following registers that do not have equivalent fields in Tool Suite:

Register	Description
0 to 11: DO, Sensor Power On	Set to (1) ON to sink current to ground when the transistor powers up. When set to (0) OFF, the transistor turns off and the output remains floating, unless the **Resistor Pull Setting** register is set to **1** or **2**.

Register	Description
40056 to 40063: Resistor Pull Setting	Select **Pull-Down** to connect a pull-down resistor to ground for use with closed-contact-to-voltage inputs. In the Modbus register, this is 1. Select **Pull-Up** to connect a pull-up resistor for closed-contact-to-ground inputs. In the Modbus register, this is 2. Select **None** to disable both resistors. In the Modbus register, this is 0.

An isolated channel configured as a Digital Output has the following specifications:

Item	Min	Typical	Max	Units
Output ON current across terminals	-	-	2	A
Output ON resistance across terminals	0	-	0.120	Ω
Output OFF resistance across terminals	10	-	-	MΩ
External AC or DC voltage connection	0	-	250	V

Isolated Channel as Digital Input

An isolated channel configured as a Digital Input provides data to the following registers:

- **10000 to 10011: DI State** - The present state of the channel.
- **30064 to 30087: DI Counter** - The number of pulse edges seen on the channel.

An isolated channel configured as a Digital Input accepts 30 V_{DC} input signals regardless of device voltage.

You can configure a Digital Input's settings in either Tool Suite or directly through the register settings. For information about setting an isolated channel as a Digital Input, see "Defining Channel Settings in Tool Suite " on page 34.

Use the information in the following table to configure a Digital Input.

Field in Tool Suite	Register	Description
Counter Edge	**96 to 106: DI Counter Falling Edge Increment**	Sets the pulse edge on which the **DI Counter** register increments. Select **Falling Edge** to increment the **DI Counter** register when the input goes from 1 to 0. In the Modbus register, this is (1) ON. Select **Rising Edge** to increment the **DI Counter** register when input goes from 0 to 1. In the Modbus register, this is (0) OFF.

Field in Tool Suite	Register	Description
Counting Speed	**92 to 95: High-Speed DI Counter on Isolated**	Determines which channels use pulse counting for input signals up to 10 kHz. If you set an input-only channel to be high-speed, its corresponding isolated channel is set to standard speed. Select **Fast** to set the channel to high-speed. In the Modbus register, this is (1) ON. You can assign high-speed counting to only one channel of 5 or 9, 6 or 10, 7 or 11, and 8 or 12. **Note:** High-speed counting is not de-bounced and inputs must not go below GND. Select **Slow** to set the channel to standard-speed. Standard speed counters support 100 Hz pulses, or 10 Hz pulses with de-bounce. In the Modbus register, this is (0) OFF.

Set the following registers that do not have equivalent fields in Tool Suite:

Register	Description
72 to 83: DI Counter Clear	Clears the Digital Input counter to 0. Critical counting ensures that each pulse is reported by only clearing pulses that you have read. For more information, see the **DI Counter Clear** register description on page 50.
136 to 147: DI Counter Latch	Allows you to scan for the input change at a much slower speed than the duration of the pulse. For more information, see the **DI Counter Latch** register description on page 50.
152 to 163: Pulse Counter De-bounce	Enables the system to take multiple samples before determining that an edge is real and not noise on the channel. Digital Inputs support pulse counting for input signals up to 100 Hz; de-bounced pulse counting for input signals to 10 Hz. **Note:** High-speed counting is not de-bounced and inputs must not go below GND.

An isolated channel configured as a Digital Input has the following specifications:

Item	Symbol	Min	Typical	Max	Units
Input Low (OFF) voltage	V_{IL}	0	-	1.2	V
Input High (ON) voltage	V_{IH}	3.2	-	30	V
Pulse counting frequency, standard speed	F_{PC}	-	-	100	Hz

Item	Symbol	Min	Typical	Max	Units
Pulse counting frequency, high speed	F_{PC}	-	-	10	kHz
Pulse counting frequency, de-bounced	F_{PCDB}	-	-	10	Hz
Pulse width, standard speed	T_{PC}	4	-	-	ms
Pulse width, high-speed	T_{PC}	40	-	-	µs
Pulse width, de-bounced	T_{PCDB}	40	-	-	ms

Chapter 3: Setting Up and Programming Serial Bases and Expansion Modules

You can setup and program Serial Bases and Expansion Modules using the Modbus registers or using the configuration tools provided in Tool Suite.

Using the Configuration application in Tool Suite, you can define the settings for the most common parameters for both the Serial Bases and their Expansion Modules in your network. You can also use the Modbus Interface application in Tool Suite to validate and troubleshoot the Modbus configuration of the devices in the stack.

The Tool Suite software is available on the *User Manual and System Tools* CD and is also available for download from www.freewave.com. For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

Reading Serial Bases and Expansion Modules in Tool Suite

Using Tool Suite, you can connect a stack of I/O devices and read and program all the devices in the stack by connecting to the last Expansion Module in the stack. When you read the device within Tool Suite, Tool Suite reads the settings starting from the Serial Base or Radio Base and for each Expansion Module in the stack.

To read and program a Serial Base and Expansion Modules using Tool Suite, you need to connect the last device in the stack to a desktop computer or a laptop that runs the Tool Suite software.

1. Connect a serial or diagnostic cable between the computer or laptop and the device.

   Using a diagnostic cable is recommended. If you need information to identify the ports, see "Expansion Module Data Connector" on page 5 and "Expansion Module Diagnostics Connector" on page 5.

2. Connect the power supply to the radio and the power source and turn on the device.
3. To place the device in Setup mode, press the Setup button on the back of the FreeWave device. .

   To place a board-level device in Setup mode, Short pins 2 & 4 (Brown to Black) on the white 10 pin header connected to the data port.

   When in Setup mode, the three LEDs on a Serial Base flash green continuously.

   Note: When a Radio Base is in Setup mode, the three LEDs on the Radio Base display solid green.
4. In Tool Suite, click **Configuration** in the Applications pane to display the Configuration application.
5. If you are using a Serial Base, click **Read Serial Base** in the Configuration ribbon to read the current settings for each device in the stack. If you are using a Radio Base, click **Read Radio**.

   Tool Suite reads the stack starting with thebase and reads each Expansion Module starting with the one connected directly to the base.

Defining Channel Settings in Tool Suite

Each Serial Base and Expansion Module comes with 12 channels as described in Chapter 2, "Channel Functions and Specifications" on page 9. Using Tool Suite, you can set whether a channel is a Digital Output, Digital Input, Analog Output, Analog Input, or a Sensor Power channel.

Important: If you change a channel to a different function, for example, if you change a Universal Channel from Digital Input to Analog Input, wait 2 seconds for reliable readings from the channel.

For more information about using Tool Suite, see the *Tool Suite User Manual* available on the *User Manual and System Tools* CD or by selecting **File > Help** in the Tool Suite software.

1. Open Tool Suite and click **Configuration** in the Applications pane to display the Configuration application.
2. From the Networks section of the Configuration ribbon, select the network in which the I/O devices reside.

   For information abut adding networks, see the Tool Suite *User Manual* available by selecting **File > Help** in the Tool Suite application.
3. Do one of the following:
   - If you want to program a device directly, see "Reading Serial Bases and Expansion Modules in Tool Suite" on page 33
   - To create a template that you can load to a device at a later time, click **Template Devices** at the bottom of the Device tree. To add a Serial Base, right-click anywhere in the Device tree and select **Add > Serial Base Template**, name the device, select the module type, and click **Add**.

     To add an Expansion Module, first add a Serial Base, then right-click the Serial Base in the Device tree and select **Add Expansion Module**. Name the device, select the module type, and click **Add**.
4. In the Device tree, select the device you want to configure.

   The current settings display in the right pane and are grouped by channel type.

If you are setting a Serial Base, you can also set the settings that apply to the entire stack. For more information, see "Settings That Apply to the Entire Stack" on page 37.

5. Click the tab that contains the channel you want to configure:
   - Universal Channels - Channels 1 to 4
   - Input-Only Channels - Channels 5 to 8
   - Isolated Channels - Channels 9 to 12.
6. In the **I/O Mode** field for the channel you want to configure, select the channel function, for example, Digital Output.

   If you are not using a channel on a device, select **Disabled** to indicate that the channel is not in use.

   The other fields that apply to the channel function you selected display when you select the channel function. For information about each parameter setting, see the descriptions of each channel type in Chapter 2, "Channel Functions and Specifications" on page 9.

   Your changes are saved to the Tool Suite database as you make them.
7. To send the configurations to a device, do one of the following:
   - To send only the parameters you have changed to a single device in the stack, select the device within the Configuration application, and click **Quick** in the Device Title ribbon. This option is only available if you clicked **Read Serial Base** and are not sending parameter settings from a template to the device.
   - To send all the settings for all parameters, select the device within the Configuration application, and click **All** in the Device Title ribbon.
   - To set a device back to its factory default settings, select the device within the Configuration application, click **Default** in the Device Title ribbon.
   - To send changes to all the devices in a stack at one time, right-click the base in the Devices tree within the Configuration application and select **Program Stack**.

Upgrading Serial Bases and Expansion Modules to the Latest Firmware

If Tool Suite is connected to a device, and a new version of the firmware is available for that model, an indication displays within the Configuration application's Device Information tab.

For more information about viewing the latest firmware versions available, see the *Tool Suite User Manual* available from the **File > Help** menu within Tool Suite.

Use the steps below to upgrade a device to the latest firmware:

1. With the device connected to Tool Suite and in Setup mode, in Tool Suite click **Configuration** in the Applications pane to display the Configuration application.
2. Click **Read Serial Base** to read the latest settings and configurations from the Serial Base and all the Expansion Modules in the stack.
3. In the Devices tree, select the device you want to upgrade.

4. Click **Upgrade Module** in the Firmware section of the Configuration ribbon.
5. Click **Yes** at the prompt to proceed or **No** to cancel without installing the new firmware.

   Tool Suite identifies and displays the firmware version that is loaded on the connected device and displays the latest version of firmware available for that model.
6. Click **Yes** to proceed with the upgrade, or **No**to exit.

   The system displays the progress of the firmware upgrade in Tool Suite. After complete, a message displays that the firmware upgrade was successful.

   While the device's firmware is being updated, each LED displays solid red .

Warning! Do not disconnect the stack from Tool Suite or from power while the firmware is updating. If the connection or power is lost during the upgrade, the device could become inoperable.

Programming Stack Settings in Tool Suite

The Serial Base contains settings, such as power settings and stack-wide Modbus settings that you program on the Serial Base device. The Serial Base then sends those settings to each Expansion Module in the stack. You can only set these settings on the Serial Base.

1. Open Tool Suite and click **Configuration** in the Applications pane to display the Configuration application.
2. From the Networks section of the Configuration ribbon, select the network in which the I/O devices reside.

   For information about adding networks, see the Tool Suite *User Manual* available by selecting **File > Help** in the Tool Suite application.
3. Do one of the following:
   - If you want to program a device directly, see "Reading Serial Bases and Expansion Modules in Tool Suite" on page 33
   - To create a template that you can load to a device at a later time, click **Template Devices** at the bottom of the Device tree. To add a Serial Base, right-click anywhere in the Device tree and select **Add > Serial Base Template**, name the device, select the module type, and click **Add**.
4. Select the device in the Device tree you want to configure and select the Stack Settings tab.
5. Make any necessary changes to the settings as described in the sections below.
6. To send the configurations to the Serial Base, do one of the following:
   - To send only the parameters you have changed to a single device in the stack, select the device within the Configuration application, and click **Quick** in the Device Title ribbon. This option is only available if you clicked **Read Serial Base** and are not sending parameter settings from a template to the device.
   - To send all the settings for all parameters, select the device within the Configuration application, and click **All** in the Device Title ribbon.
   - To set a device back to its factory default settings, select the device within the Configuration application, click **Default** in the Device Title ribbon.

Settings That Apply to the Entire Stack

The following parameters are set on the Serial Base and apply to the Serial Base and to each Expansion Module in the stack attached to the serial base. The parameters that can also be set through the Modbus inteface include the Modbus register in the description.

Set the following parameters to establish the serial port communication settings between the computer and the stack:

Field	Description
Serial Protocol	The protocol the serial port uses, RS-232, RS-422, or RS-485. **Modbus Register:** 40129 Comm Connection
Port Speed	The baud rate between the computer and the data port. The default baud rate is 19200. **Modbus Register:** 40131 Comm Port Baud Rate
Parity	The data parity of the network. The default is None. **Modbus Register:** 40132 Comm Port Parity
Stop Bits	The amount of time the transceiver stops and ways at the end of each character to wait for the next start bit. There currently is only one selection, **1-bit**. **Modbus Register:** 40133 Comm Port Stop Bits

Set the following to establish the communication timeout settings and the amount of power the stack requires:

Field	Description
Default Delay	The time the transceiver waits to receive a Modbus command or query before a communication timeout occurs. If a communication timeout occurs, the default state for the module's channels are enabled. Default states are defined in the **Default AO Command** and **Default DO, Sensor Power State** Modbus registers. If these registers are not set, the factory default settings are used.
Power Mode	Allows the Serial Base and all the Expansion Modules in the stack to use less power. The options are Regular and Low.

Set the following to establish the communication and message characteristics of the Modbus interface:

Field	Description
Modbus Address Mode	Determines the range of acceptable Modbus IDs for the device. If set to 8-Bit, the Modbus ID can be between 1 and 246. If set to 16-Bit, the Modubs ID can be between 1 and 65535.
Modbus ID	The Modbus identification number for the device. The acceptable range of IDs is determined by the **Modbus Address Mode**.

Field	Description
Modbus Message Interval	Determines the time in milliseconds **Modbus Register:** Modbus Min Transmit Inter-Message Interval
AI Integer Result Justification	Determines the alignment of the **AI Integer Result** register. Options include Left and Right.
Floating Point Word Order	Determines the position of the Most Significant Word (MSW) and Lease Significant Word (LSW) in the **AI Floating Point Result** register for all devices in the stack. Regular word order places the MSW at the lower address and the LSW at the higher address. For example MSW = 30032, LSW = 30033. Inverted word order places the LSW at the lower address and the MSW at the higher address. For example LSW = 30032, MSW = 30033).
Long Integer Word Order	Determines the position of the MSW and LSW in the **AI Result, Integer** registers for all devices in the stack. Regular word order places the MSW at the lower address and the LSW at the higher address. For example, MSW = 30000, LSW = 30001. Inverted word order places the LSW at the lower address and the MSW at the higher address. For example, LSW = 30000, MSW = 30001.

Chapter 4: Modbus Register Map

The sections below provide a map and details for each entity in the Modbus register for the I/O Expansion Module and the Serial Base. The register map is grouped by the register type:

- Holding Coils (Read/Write)
- Discrete Inputs (Read Only)
- Input Registers (Read-Only)
- Holding Registers (Read/Write)

Detailed register descriptions can be found starting on See "Holding Coils (Read/Write)" on page 50.
Registers in BLUE are non-volatile registers whose values are saved through power loss. All other register settings are lost upon power loss.

Important: Non-volatile registers have a limited number (> 10,000) of lifetime write cycles and should not be used in place of volatile settings to control I/O activity.

Note the following when using the Modbus register:

- Add 200 to the register addresses for each device in the stack to access stacked Expansion Modules. For example, if you want to set register 10004 in your 2nd expansion module, the address is 10404.
- Add 1 to registers in protocol addressing (Base 0) to obtain PLC addressing (Base 1).

For a reference of the most often used registers, see "Quick Reference" on page 40.

Important: Modbus register readings are accurate 10 seconds after powering on the device.

Quick Reference

The table below summarizes commonly used coils and registers. The complete Modbus register map and detailed descriptions follow.

Note: Protocol Addressing in the table below is Base 0.

	Universal Channels				Input-Only Channels				Isolated Channels			
Channel	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Holding (Read/Write) Coils												
Digital Output, Sensor Power Setting	0	1	2	3	-	-	-	-	8	9	10	11
Digital Input Counter Clear	72	73	74	75	76	77	78	79	80	81	82	83
Digital Input Counter Latch	136	137	138	139	140	141	142	143	144	145	146	147
Input (Read-Only) Coils												
Digital Input Status	10000	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011
Circuitry Protection Status	10024	10025	10036	10027	10028	10029	10030	10031	10032	10033	10034	10035
Input (Read-Only) Registers												
AI Integer Result	30000	30002	30004	30006	30008	30010	30012	30014	-	-	-	-
AI Floating Point Result	30032	30034	30036	30038	30040	30042	30044	30046	-	-	-	-
Digital Input Counter	30064	30066	30068	30070	30072	30074	30076	30078	30080	30082	30084	30086
Modbus Request Counter	30096	-	-	-	-	-	-	-	-	-	-	-
Digital Output Current	30112	30113	30114	30115	-	-	-	-	-	-	-	-
Device Temperature	30152	-	-	-	-	-	-	-	-	-	-	-
Device Supply Voltage	30153	-	-	-	-	-	-	-	-	-	-	-
Holding (Read/Write) Registers												
Analog Output Setting	40000	40001	40002	40003	-	-	-	-	-	-	-	-
Communication Timeout Latch	40129	-	-	-	-	-	-	-	-	-	-	-

Holding Coils (Read/Write)

Use the following Modbus command codes to read and write these coils:

- 1 - Read Coils
- 5 - Write Single Coil
- 15 - Write Multiple Coils

Add 200 to the register addresses for each device in the stack to access stacked Expansion Modules. For example, if you want to set register 10004 in your 2nd expansion module, the address is 10404.

Address Protocol	PLC	Entity	I/O Channel	Bits
0	1	DO, SENSOR POWER ON	1	1
1	2	DO, SENSOR POWER ON	2	1
2	3	DO, SENSOR POWER ON	3	1
3	4	DO, SENSOR POWER ON	4	1
8	9	DO, SENSOR POWER ON	9	1
9	10	DO, SENSOR POWER ON	10	1
10	11	DO, SENSOR POWER ON	11	1
11	12	DO, SENSOR POWER ON	12	1
24	25	APPLY DEFAULT DO, AO, SENSOR POWER	1	1
25	26	APPLY DEFAULT DO, AO, SENSOR POWER	2	1
26	27	APPLY DEFAULT DO, AO, SENSOR POWER	3	1
27	28	APPLY DEFAULT DO, AO, SENSOR POWER	4	1
32	33	APPLY DEFAULT DO, AO, SENSOR POWER	9	1
33	34	APPLY DEFAULT DO, AO, SENSOR POWER	10	1
34	35	APPLY DEFAULT DO, AO, SENSOR POWER	11	1
35	36	APPLY DEFAULT DO, AO, SENSOR POWER	12	1
48	49	DEFAULT DO, SENSOR POWER STATE	1	1
49	50	DEFAULT DO, SENSOR POWER STATE	2	1
50	51	DEFAULT DO, SENSOR POWER STATE	3	1
51	52	DEFAULT DO, SENSOR POWER STATE	4	1
56	57	DEFAULT DO, SENSOR POWER STATE	9	1
57	58	DEFAULT DO, SENSOR POWER STATE	10	1
58	59	DEFAULT DO, SENSOR POWER STATE	11	1
59	60	DEFAULT DO, SENSOR POWER STATE	12	1
72	73	DI COUNTER CLEAR	1	1
73	74	DI COUNTER CLEAR	2	1

Address Protocol	PLC	Entity	I/O Channel	Bits
74	75	DI COUNTER CLEAR	3	1
75	76	DI COUNTER CLEAR	4	1
76	77	DI COUNTER CLEAR	5	1
77	78	DI COUNTER CLEAR	6	1
78	79	DI COUNTER CLEAR	7	1
79	80	DI COUNTER CLEAR	8	1
80	81	DI COUNTER CLEAR	9	1
81	82	DI COUNTER CLEAR	10	1
82	83	DI COUNTER CLEAR	11	1
83	84	DI COUNTER CLEAR	12	1
92	93	HIGH-SPEED DI COUNTER ON ISOLATED	5, 9	1
93	94	HIGH-SPEED DI COUNTER ON ISOLATED	6, 10	1
94	95	HIGH-SPEED DI COUNTER ON ISOLATED	7, 11	1
95	96	HIGH-SPEED DI COUNTER ON ISOLATED	8, 12	1
96	97	DI COUNTER FALLING EDGE INCREMENT	1	1
97	98	DI COUNTER FALLING EDGE INCREMENT	2	1
98	99	DI COUNTER FALLING EDGE INCREMENT	3	1
99	100	DI COUNTER FALLING EDGE INCREMENT	4	1
100	101	DI COUNTER FALLING EDGE INCREMENT	5	1
101	102	DI COUNTER FALLING EDGE INCREMENT	6	1
102	103	DI COUNTER FALLING EDGE INCREMENT	7	1
103	104	DI COUNTER FALLING EDGE INCREMENT	8	1
104	105	DI COUNTER FALLING EDGE INCREMENT	9	1
105	106	DI COUNTER FALLING EDGE INCREMENT	10	1
106	107	DI COUNTER FALLING EDGE INCREMENT	11	1
107	108	DI COUNTER FALLING EDGE INCREMENT	12	1
112	113	AI SIGNED INTEGER RESULT	1	1
113	114	AI SIGNED INTEGER RESULT	2	1
114	115	AI SIGNED INTEGER RESULT	3	1
115	116	AI SIGNED INTEGER RESULT	4	1
116	117	AI SIGNED INTEGER RESULT	5	1
117	118	AI SIGNED INTEGER RESULT	6	1
118	119	AI SIGNED INTEGER RESULT	7	1
119	120	AI SIGNED INTEGER RESULT	8	1

Address Protocol	PLC	Entity	I/O Channel	Bits
120	121	AI, AO CURRENT, VOLTAGE MODE	1	1
121	122	AI, AO CURRENT, VOLTAGE MODE	2	1
122	123	AI, AO CURRENT, VOLTAGE MODE	3	1
123	124	AI, AO CURRENT, VOLTAGE MODE	4	1
124	125	AI, AO CURRENT, VOLTAGE MODE	5	1
125	126	AI, AO CURRENT, VOLTAGE MODE	6	1
126	127	AI, AO CURRENT, VOLTAGE MODE	7	1
127	128	AI, AO CURRENT, VOLTAGE MODE	8	1
136	137	DI COUNTER LATCH	1	1
137	138	DI COUNTER LATCH	2	1
138	139	DI COUNTER LATCH	3	1
139	140	DI COUNTER LATCH	4	1
140	141	DI COUNTER LATCH	5	1
141	142	DI COUNTER LATCH	6	1
142	143	DI COUNTER LATCH	7	1
143	144	DI COUNTER LATCH	8	1
144	145	DI COUNTER LATCH	9	1
145	146	DI COUNTER LATCH	10	1
146	147	DI COUNTER LATCH	11	1
147	148	DI COUNTER LATCH	12	1
152	153	PULSE COUNTER DEBOUNCE	1	1
153	154	PULSE COUNTER DEBOUNCE	2	1
154	155	PULSE COUNTER DEBOUNCE	3	1
155	156	PULSE COUNTER DEBOUNCE	4	1
156	157	PULSE COUNTER DEBOUNCE	5	1
157	158	PULSE COUNTER DEBOUNCE	6	1
158	159	PULSE COUNTER DEBOUNCE	7	1
159	160	PULSE COUNTER DEBOUNCE	8	1
160	161	PULSE COUNTER DEBOUNCE	9	1
161	162	PULSE COUNTER DEBOUNCE	10	1
162	163	PULSE COUNTER DEBOUNCE	11	1
163	164	PULSE COUNTER DEBOUNCE	12	1

Discrete Inputs (Read-Only)

Use the following Modbus command codes to read these discrete inputs:

- 2: Read Discrete Inputs

Add 200 to the register addresses for each device in the stack to access stacked Expansion Modules. For example, if you want to set register 10004 in your 2nd expansion module, the address is 10404.

Address Protocol	PLC	Entity	I/O Channel	Bits
10000	10001	DI STATE	1	1
10001	10002	DI STATE	2	1
10002	10003	DI STATE	3	1
10003	10004	DI STATE	4	1
10004	10005	DI STATE	5	1
10005	10006	DI STATE	6	1
10006	10007	DI STATE	7	1
10007	10008	DI STATE	8	1
10008	10009	DI STATE	9	1
10009	10010	DI STATE	10	1
10010	10011	DI STATE	11	1
10011	10012	DI STATE	12	1
10024	10025	CIRCUITRY PROTECTION ACTIVE	1	1
10025	10026	CIRCUITRY PROTECTION ACTIVE	2	1
10026	10027	CIRCUITRY PROTECTION ACTIVE	3	1
10027	10028	CIRCUITRY PROTECTION ACTIVE	4	1
10028	10029	CIRCUITRY PROTECTION ACTIVE	5	1
10029	10030	CIRCUITRY PROTECTION ACTIVE	6	1
10030	10031	CIRCUITRY PROTECTION ACTIVE	7	1
10031	10032	CIRCUITRY PROTECTION ACTIVE	8	1
10032	10033	CIRCUITRY PROTECTION ACTIVE	9	1
10033	10034	CIRCUITRY PROTECTION ACTIVE	10	1
10034	10035	CIRCUITRY PROTECTION ACTIVE	11	1
10035	10036	CIRCUITRY PROTECTION ACTIVE	12	1

Input Registers (Read-Only)

Use the following Modbus command codes to read these registers:

- 4 - Read Input Registers

Add 200 to the register addresses for each device in the stack to access stacked Expansion Modules. For example, if you want to set register 10004 in your 2nd expansion module, the address is 10404.

Address Protocol	PLC	Entity	I/O Channel	Bits
30000/30001	30001/30002	AI INTEGER RESULT	1	32
30002/30003	30003/30004	AI INTEGER RESULT	2	32
30004/30005	30005/30006	AI INTEGER RESULT	3	32
30006/30007	30007/30008	AI INTEGER RESULT	4	32
30008/30009	30009/30010	AI INTEGER RESULT	5	32
30010/30011	30011/30012	AI INTEGER RESULT	6	32
30012/30013	30013/30014	AI INTEGER RESULT	7	32
30014/30015	30015/30016	AI INTEGER RESULT	8	32
30032/30033	30033/30034	AI FLOATING POINT RESULT	1	32
30034/30035	30035/30036	AI FLOATING POINT RESULT	2	32
30036/30037	30037/30038	AI FLOATING POINT RESULT	3	32
30038/30039	30039/30040	AI FLOATING POINT RESULT	4	32
30040/30041	30041/30042	AI FLOATING POINT RESULT	5	32
30042/30043	30043/30044	AI FLOATING POINT RESULT	6	32
30044/30045	30045/30046	AI FLOATING POINT RESULT	7	32
30046/30047	30047/30048	AI FLOATING POINT RESULT	8	32
30064/30065	30065/30066	DI COUNTER	1	32
30066/30067	30067/30068	DI COUNTER	2	32
30068/30069	30069/30070	DI COUNTER	3	32
30070/30071	30071/30072	DI COUNTER	4	32
30072/30073	30073/30074	DI COUNTER	5	32
30074/30075	30075/30076	DI COUNTER	6	32
30076/30077	30077/30078	DI COUNTER	7	32
30078/30079	30079/30080	DI COUNTER	8	32
30080/30081	30081/30082	DI COUNTER	9	32
30082/30083	30083/30084	DI COUNTER	10	32
30084/30085	30085/30086	DI COUNTER	11	32
30086/30087	30087/30088	DI COUNTER	12	32

Address Protocol	PLC	Entity	I/O Channel	Bits
30096	30097	MODBUS REQUEST COUNTER	-	16
30112	30113	DO CURRENT	1	16
30113	30114	DO CURRENT	2	16
30114	30115	DO CURRENT	3	16
30115	30116	DO CURRENT	4	16
30116	30117	DO CURRENT	5	16
30117	30118	DO CURRENT	6	16
30118	30119	DO CURRENT	7	16
30119	30120	DO CURRENT	8	16
30152	30153	DEVICE TEMPERATURE	-	16
30153	30154	VBATT VOLTAGE	-	16

Holding Registers (Read/Write)

Use the following Modbus command codes to read and write these registers:

- 3 - Read Holding Registers
- 6 - Write Single Register
- 16 - Write Multiple Registers

Add 200 to the register addresses for each device in the stack to access stacked Expansion Modules. For example, if you want to set register 10004 in your 2nd expansion module, the address is 10404.

Address Protocol	PLC	Entity	I/O Channel	Bits
40000	40001	AO COMMAND	1	16
40001	40002	AO COMMAND	2	16
40002	40003	AO COMMAND	3	16
40003	40004	AO COMMAND	4	16
40008	40009	DEFAULT AO COMMAND	1	16
40009	40010	DEFAULT AO COMMAND	2	16
40010	40011	DEFAULT AO COMMAND	3	16
40011	40012	DEFAULT AO COMMAND	4	16
40016	40017	CHANNEL MODE	1	16
40017	40018	CHANNEL MODE	2	16
40018	40019	CHANNEL MODE	3	16
40019	40020	CHANNEL MODE	4	16
40020	40021	CHANNEL MODE	5	16
40021	40022	CHANNEL MODE	6	16
40022	40023	CHANNEL MODE	7	16
40023	40024	CHANNEL MODE	8	16
40024	40025	CHANNEL MODE	9	16
40025	40026	CHANNEL MODE	10	16
40026	40027	CHANNEL MODE	11	16
40027	40028	CHANNEL MODE	12	16
40040	40041	AI FILTER SETTING	1	16
40041	40042	AI FILTER SETTING	2	16
40042	40043	AI FILTER SETTING	3	16
40043	40044	AI FILTER SETTING	4	16
40044	40045	AI FILTER SETTING	5	16

Address Protocol	PLC	Entity	I/O Channel	Bits
40045	40046	AI FILTER SETTING	6	16
40046	40047	AI FILTER SETTING	7	16
40047	40048	AI FILTER SETTING	8	16
40056	40057	RESISTOR PULL SETTING	1	16
40057	40058	RESISTOR PULL SETTING	2	16
40058	40059	RESISTOR PULL SETTING	3	16
40059	40060	RESISTOR PULL SETTING	4	16
40060	40061	RESISTOR PULL SETTING	5	16
40061	40062	RESISTOR PULL SETTING	6	16
40062	40063	RESISTOR PULL SETTING	7	16
40063	40064	RESISTOR PULL SETTING	8	16
40072	40073	AO RESOLUTION	1	16
40073	40074	AO RESOLUTION	2	16
40074	40075	AO RESOLUTION	3	16
40075	40076	AO RESOLUTION	4	16
40080	40081	DO MONOSTABLE TIMEOUT	1	16
40081	40082	DO MONOSTABLE TIMEOUT	2	16
40082	40083	DO MONOSTABLE TIMEOUT	3	16
40083	40088	DO MONOSTABLE TIMEOUT	4	16
40088	40089	DO MONOSTABLE TIMEOUT	9	16
40089	40090	DO MONOSTABLE TIMEOUT	10	16
40090	40091	DO MONOSTABLE TIMEOUT	11	16
40091	40092	DO MONOSTABLE TIMEOUT	12	16
40096	40097	AI ZERO VOLTAGE	1	16
40097	40098	AI ZERO VOLTAGE	2	16
40098	40099	AI ZERO VOLTAGE	3	16
40099	40100	AI ZERO VOLTAGE	4	16
40100	40101	AI ZERO VOLTAGE	5	16
40101	40102	AI ZERO VOLTAGE	6	16
40102	40103	AI ZERO VOLTAGE	7	16
40103	40104	AI ZERO VOLTAGE	8	16
40104	40105	AI VOLTAGE SPAN	1	16
40105	40106	AI VOLTAGE SPAN	2	16
40106	40107	AI VOLTAGE SPAN	3	16

Address Protocol	PLC	Entity	I/O Channel	Bits
40107	40108	AI VOLTAGE SPAN	4	16
40108	40109	AI VOLTAGE SPAN	5	16
40109	40110	AI VOLTAGE SPAN	6	16
40110	40111	AI VOLTAGE SPAN	7	16
40111	40112	AI VOLTAGE SPAN	8	16
40112	40113	AI, AO ZERO CURRENT	1	16
40113	40114	AI, AO ZERO CURRENT	2	16
40114	40115	AI, AO ZERO CURRENT	3	16
40115	40116	AI, AO ZERO CURRENT	4	16
40116	40117	AI, AO ZERO CURRENT	5	16
40117	40118	AI, AO ZERO CURRENT	6	16
40118	40119	AI, AO ZERO CURRENT	7	16
40119	40120	AI, AO ZERO CURRENT	8	16
40120	40121	AI, AO CURRENT SPAN	1	16
40121	40122	AI, AO CURRENT SPAN	2	16
40122	40123	AI, AO CURRENT SPAN	3	16
40123	40124	AI, AO CURRENT SPAN	4	16
40124	40125	AI, AO CURRENT SPAN	5	16
40125	40126	AI, AO CURRENT SPAN	6	16
40126	40127	AI, AO CURRENT SPAN	7	16
40127	40128	AI, AO CURRENT SPAN	8	16
40128	40129	COMM CONNECTION	-	16
40129	40130	COMM TIMEOUT LATCH	-	16
40130	40131	COMM PORT BAUD RATE	-	16
40131	40132	COMM PORT PARITY	-	16
40132	40133	COM PORT STOP BITS	-	16
40133	40134	MODBUS MIN TRANSMIT INTER-MSG INTERVAL	-	16
40134	40135	RS485 TURN ON DELAY	-	16
40135	40136	RS485 TURN OFF DELAY	-	16

Modbus Register Descriptions

This section describes the functionality of each register in detail. The register addresses are referenced in protocol addressing (Base 0). For PLC addressing (Base 1), add 1 to each register address listed.

Important: Modbus register readings are accurate 10 seconds after powering on the device.

Add 200 to the register addresses for each device in the stack to access stacked Expansion Modules. For example, if you want to set register 10004 in your 2nd expansion module, the address is 10404.

Holding Coils (Read/Write)

0 to 11: DO, Sensor Power ON

Upon power up, this register takes the state of **Default DO, Sensor Power State** if the **Apply Default DO, AO, Sensor Power** register is set to (1) ON.

- **Universal Channel as Digital Output** - When a universal channel is configured as Digital Output and this coil is set to (1) ON, the transistor turns on and sinks current to ground. When this coil is set to (0) OFF, the transistor turns off and the output remains floating, unless the internal pull-up or pull-down resistor is enabled. For more information about the Resistor Pull Setting, see the register description on page 54.
- **Universal Channel as Sensor Power** - When a universal channel is configured as Sensor Power and this coil is set to (1) ON, then VBATT is applied to this channel through protection circuitry. When this coil is set to (0) OFF, then no power is applied to the channel. If Sensor Power should be applied on power up, then registers **24 to 35: Apply Default DO, AO, Sensor Power** and **48 to 59: Default DO, Sensor Power State** must be set to ON (1) for the appropriate channel.
- **Isolated Channel as Digital Output** - When an isolated channel is configured as Digital Output and this coil is set to (1) ON, the relay closes and the terminals are shorted together. When this coil is set to (0) OFF, the relay opens and the terminals for the channel are left floating.

24 to 35: Apply Default DO, AO, Sensor Power

This register is used upon device power up and upon communication timeout.

If this register is set to (1) ON, upon power up, channels configured as Digital Output, Analog Output, and Sensor Power output their default values. If this register is set to (0) OFF, then factory default values are applied upon power up.

Every device has a timer that is reset when it receives a Modbus command or query. If the device does not receive a Modbus command or query for the time set in the **Default Delay** parameter in the Stack Settings tab in Tool Suite, then a communication timeout occurs. If a communication timeout occurs and this register is set to (1) ON, the channels configured as Digital Output, Analog Output, or Sensor Power changes outputs to the default settings. If this register is set to (0) OFF, then the channel outputs do not change.

48 to 59: Default DO, Sensor Power State

The default state for channels configured as Digital Output and Sensor Power. For this setting to apply, register **24 to 35: Apply Default DO, AO, Sensor Power** register must be set to (1) ON for the channel.

72 to 83: DI Counter Clear

This register clears the Digital Input counters in one of two ways:

- Writing 1 to this register forces the counter to 0. This method forces the count to 0 even if pulses have arrived since the last counter read.
- Writing 0 clears the register in a way called *critical counting*. Critical counting is a function that keeps track of all the pulses that have been reported. By clearing this register with critical counting, then the counter is set to the number of pulses that have arrived since the last counter read. In this way, you can keep track of each pulse that arrives.

92 to 95: High–Speed DI Counter on Isolated

There are four high-speed Digital Input counters available that support counting up to 10 kHz. Use this register to select which channel to use as high-speed counters. If a channel is not assigned to high-speed counting it supports standard speed counting. Standard-speed counters support 100 Hz pulses, or 10 Hz pulses with de-bounce.

- Setting coil 92 to (1) ON sets channel 9 to high-speed and channel 5 to standard speed. Setting to (0) OFF sets channel 9 to standard-speed and channel 5 to high-speed.
- Setting coil 93 to (1) ON sets channel 10 to high-speed and channel 6 to standard speed. Setting to (0) OFF sets channel 10 to standard-speed and channel 6 to high-speed.
- Setting coil 94 to (1) ON sets channel 11 to high-speed and channel 7 to standard speed. Setting to (0) OFF sets channel 11 to standard-speed and channel 7 to high-speed.
- Setting coil 95 to (1) ON sets channel 12 to high-speed and channel 8 to standard speed. Setting to (0) OFF sets channel 12 to standard-speed and channel 8 to high-speed.

96 to 106: DI Counter Falling Edge Increment

When this coil is (1) ON, the counter for a Digital Input is incremented when the input goes from 1 to 0 (a falling edge).

When this coil is (0) OFF, the counter for a Digital Input is incremented when the input goes from 0 to 1 (on a rising edge).

112 to 119: AI Signed Integer Result

When a channel is configured as Analog Input and this coil is (1) ON, the **AI Integer Result** register is a signed number. A signed number is necessary to report negative input voltages or if the RTU/PLC supports signed results only.

When this register is set to (0) OFF, the **AI Integer Result** register is an unsigned number. The default is (0) OFF.

120 to 127: AI, AO Current, Voltage Mode

When set to (1) ON, an internal 250 ohm sense resistor is turned on to report 4 to 20 mA inputs. The complete current range is from 0 to 25 mA.

Setting this coil to (0) OFF disables the sense resistor and supports reading voltage input. This is needed for 1 to 5 V and 0 to 10 V transmitters. The complete voltage range is from -2.5 to +12.5 V.

136 to 147: DI Counter Latch

This register is set to ON internally when the **DI Counter** register is incremented. This is useful for systems that poll the Digital Input states at slower speeds than the duration of Digital Input signals. Write 0 to this register to clear the latch.

152 to 163: Pulse Counter De-Bounce

If set to (0) OFF, there is no software processing and noise can be treated as signal (false counts may be encountered). If set to (1) ON, the software takes multiple samples before deciding that an edge is a real edge not noise. The price is drastic reduction in max frequency that can be counted from 800 Hz to 10 Hz.

Discrete Inputs (Read-Only)

10000 to 10011: DI State

This input reports the present state of the channel configured as Digital Input.

10024 to 10035: Circuitry Protection Active

This input reports the status of circuitry protection on the channel. Circuitry protection is used in Digital Output, Analog Input in current mode, and Sensor Power modes. When this coil is (1) ON, an overload condition has been detected and the channel function is disabled for a short time.

The channel is retried at 10 second intervals to test whether the overload condition has been removed.

When the channel is within its limits, this register is (0) OFF.

Input Registers (Read-Only)

30000 to 30016: AI Integer Result

This register contains the most recent Analog Input conversion result reported as an integer. The scale of the **AI Integer Result** depends on the settings in the **AI Voltage Span** and **AI AO Current Span** registers.

The **Long Integer Word Order** setting on the Serial Base determines the position of the MSW and LSW in the **AI Integer Result** registers for all devices in the stack. Regular word order places the MSW at the lower address and the LSW at the higher address (ex: MSW = 30000, LSW = 30001). Inverted word order places the LSW at the lower address and the MSW at the higher address (ex: LSW = 30000, MSW = 30001). **Long Integer Word Order** helps connections with controllers that only accept one word order or another.

> **Note:** When a Radio Base is used then the **Long Integer Word Order** is forced to regular.

The **AI Integer Result Justification** setting on the Serial Base determines the position of the **AI Result Integer** inside the 32-bit registers. Left justification places the most significant 16 bits of the AI Result in the MSW. Left justification is commonly used to access only the most significant 16 bits. With left justification you can access only 1 register and obtain a 16-bit integer. Right justification places the least significant 16 bits of the **AI Result** in the Least Significant Word (LSW). Right justification is commonly used to access the

complete 20-bit result. With left justification you generally read 2 registers and obtain a 32-bit integer containing a 20-bit AI Result. When a Radio Base is used, then the **AI Integer Result Justification** is forced to left.

30032 to 30047: AI Result, Floating Point

This register contains the most recent Analog Input conversion result reported as a floating point number. The decimal number represents the actual voltage in V or current in mA. The setting in registers **121 to 128: AI Current Mode** determines whether the channel is used in current or voltage mode.

The **Floating Point Word Order** setting on the Serial Base determines the position of the MSW and LSW in the AI Result, Floating Point registers for all devices in the stack. Regular word order places the MSW at the lower address and the LSW at the higher address (ex: MSW = 30032, LSW = 30033). Inverted word order places the LSW at the lower address and the MSW at the higher address (ex: LSW = 30032, MSW = 30033). When a Radio Base is used then the **Long Integer Word Order** is forced to regular. This setting allows controllers that require reverse register order to access 32-bit floating point registers without additional programming.

30064 to 30087: DI Counter

The **DI Counter** reports the number of pulse edges seen on a Digital Input. The pulse edge (rising edge or falling edge) that increments the **DI Counter** is set by coils **96 to 107: DI Counter Falling Edge Increment**. You can read both the MSW and LSW for a 32-bit unsigned integer. Alternatively, you can read the LSW to gain access to a 16-bit unsigned integer result.

- The maximum counting rate for de-bounced counters is 10 Hz with a minimum pulse width of 40 ms.
- The maximum counting rate for standard-speed counters is 100 Hz with a minimum pulse width of 4 ms.
- The maximum counting rate for high-speed counters is 10 kHz with a minimum pulse width of 40 µs.

Whether a channel is standard-speed or high-speed is determined by the setting of coils **92 to 95: High-speed DI Counter On Isolated**.

The **Long Integer Word Order** setting on the Serial Base applies to these registers. See the AI Integer Result register description on previous page for a description of the **Long Integer Word Order** setting.

30096: Modbus Request Counter

This register is a running total of Modbus requests. Every time a Modbus request is received and processed this register is incremented. This is useful for PLCs and RTUs that do not handle Modbus failures appropriately. If the PLC or RTU reports the same number in this register time after time despite continuous polling attempts, then communication has failed between the PLC and the I/O Expansion device.

30112 to 30119: DO Current

This register represents the current in milliAmps flowing through Digital Output channels set to (1) ON. It is not meant to accurately measure the current to report an approximate current confirming flow.

30152: Device Temperature

The temperature of the device circuit board reported as a signed integer with units of 1° C per Least Significant Bit (lsb).

30153: VBATT

The supply voltage to the device as an unsigned integer reported in 1 mV per LSb. This is useful to remotely monitor the battery level.

Holding Registers (Read/Write)

40000 to 40003: AO Command

The analog value to output when a channel is used as Analog Output.

When registers **40072 to 40075: AO Resolution** are set to **0** then the scaling factor is 1 µA per bit. When registers **40072 to 40075: AO Resolution** are not **0**, then the scaling factor is determined by registers **40120 to 40127: AI, AO Current Span**.

In both cases case, the value in the **40112 to 40119: AI, AO Zero Current** register is added to the **AO Command** register and the sum is the actual current output. However, the output cannot be higher than 22 mA. If the sum of the **AI, AO Zero Current** register and the **AO Command** register is greater than 22 mA, the value of the **AO Command** is capped to reach the maximum output of 22 mA.

40008 to 40011: Default AO Command

The value in this register is the **AO Command** in default conditions.

40016 to 40027: Channel Mode

This register sets the channel to be one of the following types:

- 0 - Off
- 1 - Digital Output
- 2 - Digital Input
- 3 - Analog Output
- 4 - Analog Input
- 5 - Sensor Power

Important: If you change a channel to a different function, for example, if you change a Universal Channel from Digital Input to Analog Input, wait 2 seconds for reliable readings from the channel.

40040 to 40047: AI Filter Setting

The filter setting turns on filtering (a moving average) for **AI Integer Result** and **AI Floating Point Result**. Use filtering to reduce signal noise by providing a stable reading. Setting this register to 0 disables filtering. Setting this register to values from 1 to 5 increases the filtering/averaging times:

- 1 - 10 seconds (0.1 Hz)
- 2 - 25 seconds (0.04 Hz)
- 3 - 50 seconds (0.02 Hz)

- 4 - 100 seconds (0.01 Hz)
- 5 - 250 seconds (0.004 Hz)

40056 to 40063: Resistor Pull Setting

Setting this coil to 1 connects a 10 kΩ pull-down resistor to ground for use with closed-contact-to-voltage inputs and outputs. Setting this coil to 2 connects a 1 kΩ pull-up resistor to 3 V for closed-contact-to-ground inputs and outputs. Setting this coil to 0 disables both resistors.

40072 to 40075: AO Resolution

Use these registers to change the scaling of **AO Command**. Some PLCs and RTUs support only 16 bits, 14 bits, 12 bits, or signed integers. The **AO Command** scaling depends on this setting:

- 0 - 1 µA per bit
- 16-bit resolution
- 15-bit resolution (This is the recommended setting for PLCs or RTUs that only support 16-bit signed integers.)
- 14-bit resolution
- 12-bit resolution

40080 to 40091: DO Monostable Timeout

When this register is set to a number other than 0, the mono-stable setting is enabled. Enter the amount of time in milliseconds from 1 to 60000 (1 minute) after which the Digital Output goes to its default state as defined in register **48 to 59: Default DO, Sensor Power State**.

When this register is set to 0, the Digital Output is bi-stable and the monostable time out is no longer enabled. A bi-stable Digital Output maintains the last state until a command is received that changes the Digital Output state.

40096 to 40103: AI Zero Voltage

This register is the voltage that results in the Analog Input reporting 0 in the **AI Integer Result** register. The scaling factor for this register is 1 mV per bit and the valid range is from 0 to 10000 mV. It is useful for translating offset sensors such as 1 to 5 V transmitters so that their minimum output reports 0 in the **AI Integer Result** register. It is also useful for adjusting AI readings to provide calibration capabilities.

See **40104 to 40111: AI Voltage Span** for recommended settings with 1 to 5 V and 0 to 10 V sensors.

40104 to 40111: AI Voltage Span

This register sets the span and scaling factor for **AI Integer Result**. This register added to **AI Zero Voltage** is the voltage that results in full scale in **AI Integer Result**. For 16-bit readings, full scale is 65535, and for 20-bit readings full scale is 1,048,575.

The scaling factor for this register is 1 mV per bit and the valid range is from 0 to 12,500 mV. It is useful for translating sensors such as 1 to 5 V transmitters so their maximum output reports full scale in the **AI Integer Result** register.

Recommended settings for 1 to 5 V sensors:

- Set **AI Zero Voltage** to 1000 (equal to 1 V)
- Set **AI Voltage Span** is 4000 (equal to 4 V = 5 V – 1V)
- When reading the full 20-bit result, the scaling factor is 3.8147 mV per LSB
- When reading only the most significant 16 bits, the scaling factor is 61.035 mV per LSB

Recommended settings for 0 to 10 V sensors:

- Set AI Zero Voltage to 0 (equal to 0 V)
- Set AI Voltage Span to 10000 (equal to 10 V)
- When reading the full 20-bit result in **AI Integer Result**, the scaling factor is 3.8147 mV per LSB
- When reading only the most significant 16 bits in **AI Integer Result**, the scaling factor is 61.035 mV per LSB

For other input ranges or for fine tuning the inputs above:

- Set **AI Zero Voltage** to the minimum input voltage
- Set **AI Voltage Span** to the input span = maximum input voltage - minimum input voltage
- When reading the full 20-bit result, the scaling factor is **AI Voltage Span** / 1048576
- When reading only the most significant 16 bits, the scaling factor is **AI Voltage Span** / 65536

For backwards compatibility, a setting of 0 forces the **AI Voltage Span** to 10000 mV.

40112 to 40119: AI, AO Zero Current

When the channel is used as an Analog Input this register is the current that results in the Analog Input reporting 0 in the **AI Integer Result** register. The scaling factor for this register is 1 µA per bit and the valid range is from 0 to 25000 µA. This register is useful for translating offset sensors such as 4 to 20 mA transmitters so that their minimum output reports 0 in the **AI Integer Result** register. It is also useful for adjusting Analog Input readings to provide calibration capabilities.

When the channel is used as an Analog Output this register is the current that is output when the **AO Command** register is set to 0. The scaling factor for this register is 1 µA per bit and the valid range is from 0 to 25000 µA. This register is useful for outputting 4 to 20 mA signals so that their minimum output is 4 mA when the **AO Command** register is 0.

Ses the description for **40120 to 40127: AI, AO Current Span** below for recommended settings with 4 to 20 mA sensors.

40120 to 40127: AI, AO Current Span

The scaling factor for this register is 1 µA per bit and the valid range is from 0 to 25,000 µA. This register is useful for translating sensors such as 4 to 20 mA transmitters so that their maximum output reports full scale in the **AI Integer Result** register. For 16-bit readings full scale is 65535, and for 20-bit readings full scale is 1,048,575.

When the channel is used as an Analog Input this register sets the span and scaling factor for the **AI Integer Result** register. This register added to **AI, AO Zero Current** is the input current that results in full scale in the **AI Integer Result** register.

Recommended settings for 4 to 20 mA sensor inputs:

- Set **AI Zero Voltage** to 4000 (equal to 4 mA)
- Set **AI Voltage Span** to 16000 (equal to 16 mA = 20 mA – 4 mA)
- When reading the full 20-bit result in **AI Integer Result**, the scaling factor is 15.259 nA per LSB
- When reading only the most significant 16 bits in **AI Integer Result**, the scaling factor is 244.14 nA per LSB

For all other input ranges or for fine tuning the inputs above:

- Set **AI Zero Voltage** to the minimum input voltage
- Set **AI Voltage Span** to the output span = maximum input current - minimum input voltage
- When reading the full 20-bit result in **AI Integer Result**, the scaling factor is **AI Voltage Span** / 1048576
- When reading only the most significant 16 bits in **AI Integer Result**, the scaling factor is **AI Voltage Span** / 65536

When the channel is used as an Analog Output this register sets the span and scaling factor for the **AO Command** register. This register added to **AI, AO Zero Current** is the output current when full scale is entered into **AO Command**.

Recommended settings for 4 to 20 mA outputs:

- Set **AI, AO Zero Voltage** to 4000 (equal to 4 mA)
- Set **AI, AO Voltage Span** is 16000 (equal to 16 mA = 20 mA – 4 mA)
- When writing all 16 bits in **AO Command**, the scaling factor is 244.14 nA per LSB
- When writing all 15 bits in **AO Command**, the scaling factor is 122.07 nA per LSB
- When writing all 14 bits in **AO Command**, the scaling factor is 61.035 nA per LSB
- When writing all 12 bits in **AO Command**, the scaling factor is 15.259 nA per LSB

For all other output ranges or for fine-tuning the inputs above:

- Set **AI, AO Zero Voltage** to the minimum output current
- Set **AI, AO Voltage Span** to the output span = maximum input current - minimum input voltage
- When writing all 16 bits in **AO Command**, the scaling factor is **AI Voltage Span** / 65536
- When writing all 15 bits in **AO Command**, the scaling factor is **AI Voltage Span** / 32768
- When writing all 14 bits in **AO Command**, the scaling factor is **AI Voltage Span** / 16384
- When writing all 12 bits in **AO Command**, the scaling factor is **AI Voltage Span** / 4096

For backwards compatibility, a setting of 0 forces the **AI, AO Current Span** to 20000 µA.

40128: Comm Connection

The serial port connector type of a Serial Base: RS-232 (0), RS-422 (1), or RS-485 (2).

40129: Comm Timeout Latch

In case of communication failure, channels configured as Digital Output, Analog Output, and Sensor Power can be set up to go to default states. This register serves to inform (after communication is restored) that the

communication timeout occurred long enough to activate the defaults. This register remains at (1) ONN until set to (0) OFF by Modbus command. Setting to 0 clears the latch.

40130: Comm Port Baud Rate

The baud rate of the serial port. The default setting is (0) 19200. Options include the following:

- (0) 19200
- (1) 150
- (2) 300
- (3) 600
- (4) 1200
- (5) 2400
- (6) 4800
- (7) 9600
- (8) 14400
- (9) 19200
- (10) 28800
- (11) 38400
- (12) 57600
- (13) 76800
- (14) 115200
- (15) 153600
- (16) 230400

40131: Comm Port Parity

The parity of the port connected to the device. Options include the following:

- (0) None
- (1) Even
- (2) Odd

40132: Comm Port Stop Bits

There currently is only one selection for Com Port Parity: (1) Even.

40133: Modbus Min Transmit Inter-Message Interval

The interval cannot be shorter than 2 ms; regardless of a setting in this register, the interval is automatically adjusted to be shorter than 3.5 character lengths.

On the receive side, the interval between messages must be at least 2 ms. If the interval is less than 0.4 ms, received characters will be processed as one message. If the interval is between 0.4 and 2 ms, the Modbus message processing will not be reliable.

40134: RS-485 Turn-On Delay

If the **Comm Connection** register is set to (2) RS-485, set the number of milliseconds (ms) between the RS-485 transmitter turning on and the character transmission start. Set the delay between 0 and 10 ms. The default setting is 1 ms.

40135: RS-485 Turn-Off Delay

If the **Comm Connection** register is set to (2) RS-485, set the number of milliseconds (ms) between the RS-485 character transmission end and the transmitter turning off. Set the delay between 0 and 10 ms. The default setting is 1 ms.

Modbus Timing

Communication from the Base Modules to Expansion Modules occurs on a bus architecture. The bus architecture provides the fastest communication times for the entire stack because all Expansion Modules see the message from the Base at the same time. There is no difference in messaging times or execution times whether there is one Expansion Module in a stack or fifteen.

The Modbus command response time is the time it takes a device to interpret and respond to a Modbus command or query. For example, polling the value of a 4 to 20 mA input.

Modbus Command Response Time by Device and Command Type	Serial Base	Expansion Module	Expansion Module	Expansion Module	
Stack ID	**0**	**1**	**2**	**15**	**Units**
Command 1: Read Coils					
1 coil	4	11	11	11	ms
160 coils	6	14	14	14	ms
Command 2: Read Discrete Inputs					
1 discrete input	4	11	11	11	ms
80 discrete inputs	6	12	12	12	ms
Command 3: Read Holding Registers					
1 holding register	4	11	11	11	ms
125 holding registers	18	52	52	52	ms
Command 4: Read Input Registers					
1 input register	4	11	11	11	ms
125 input registers	18	52	52	52	ms
Command 5: Write Single Coil	4	11	11	11	ms
Command 6: Write Single Register	4	11	11	11	ms
Command 15: Write Multiple Coils					
2 coils	4	11	11	11	ms
120 coils	6	14	14	14	ms
Command 16: Write Multiple Registers					
2 holding registers	4	11	11	11	ms
123 holding registers	11	43	43	43	ms

The output execution delay time is the time it takes a device to execute a command (for example, change a Digital Output from low to high). The time is referenced from the moment the complete Modbus command arrives at the data port.

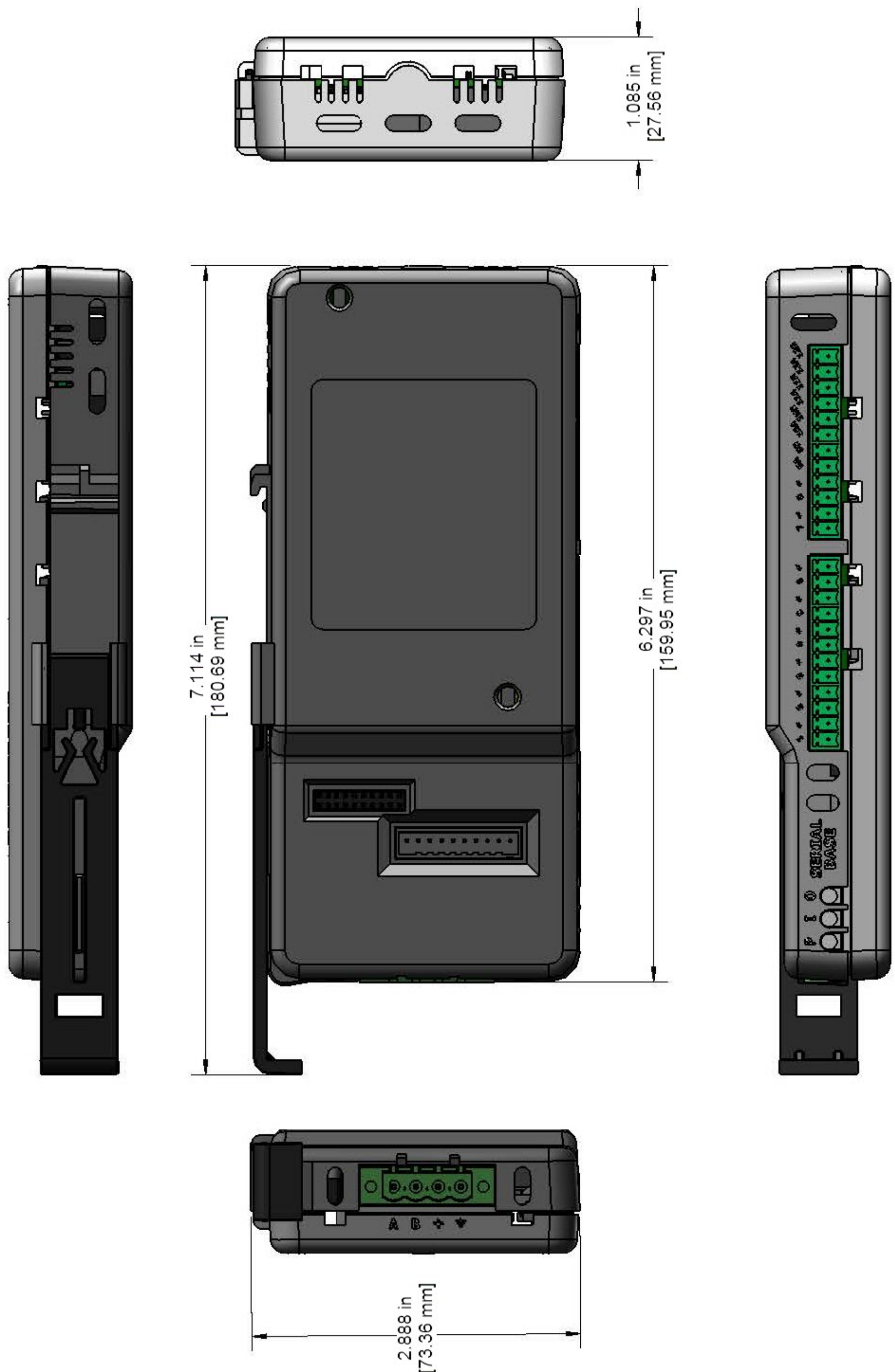
Modbus Output Execution Delay Time by Device and I/O Type	Serial Base	Expansion Module	Expansion Module	Expansion Module	
	0	1	2	15	Units
Non-Isolated Digital Output					
Command 5 (writing 1 coil)	3	6	6	6	ms
Command 15 (writing 120 coils)	3	8	8	8	ms
Isolated Digital Output					
Command 5 (writing 1 coil)	17	14	14	14	ms
Command 15 (writing 120 coils)	18	16	16	16	ms
Analog Output					
Command 6 (writing 1 registers)	3	6	6	6	ms
Command 16 (writing 123 registers)	3	33	33	33	ms

Chapter 5: Additional I/O Expansion Information

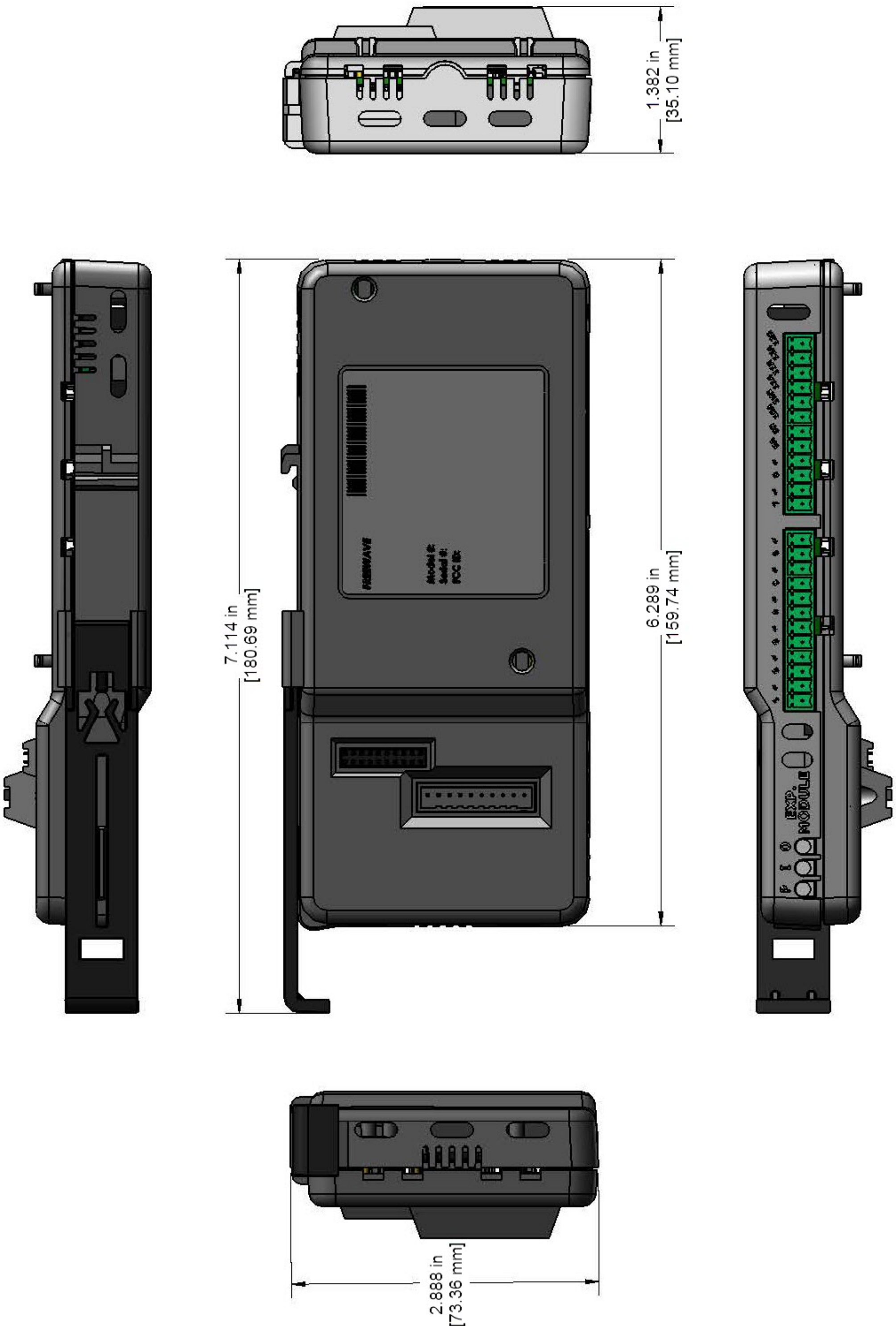
This chapter provides the following additional information about Serial Bases and Expansion Modules:

- Dimensions
- Other physical information about the devices

Serial Base Dimensions



Expansion Module Dimensions



Physical Specifications

Housing	High-impact plastic
Mounting	Integrated 35 mm DIN rail clip
Weight	0.35 lbs
Temperature	-40° C to 75° C
Humidity	0 to 95% non-condensing

Appendix A: Firmware updates

As of this document's release, the following firmware has been released for the model numbers to which this document applies. The latest firmware versions are available on the FreeWave Web site at www.freewave.com. You can also view the latest firmware available for most models in Tool Suite.

The sections below describe the updates in each firmware revision for the I/O Serial Bases and Expansion Modules. The most recent version is listed first.

Version 2.2.0

Release Date:	January 2012
Additions/Updates:	• The **40000 to 40003: AO Command** register cannot exceed the max output current of 22 mA. If the **AO Command** register is set so the value of that register and the **40112 to 40119: AI, AO Zero Current** register together are more than 22 mA, the **AO Command** current is capped so the total current does not exceed 22 mA. • Corrected power LED blinking issue. • Corrected reporting of a signed analog input value. • Fixed a pulse counter bug.
Known Limitations:	None

Version 2.1.0

Release Date: August 2011

Additions/Updates:

- Added support for 153.6 and 230.4 kbaud data rates. Removed 110 kbaud support.
- Increased max pulse counting frequency to 800 Hz with 60/40 duty cycle.
- Added software pulse counter de-bouncing. With de-bouncing, the maximum counting frequency is 10 Hz; without de-bouncing the maximum counting frequency, as stated above.
- You can now set the pull-up resistor and pull-down resisters for a Digital Output using the same register and hardware as the Digital Input.
- Reduced max digital output current from 25 mA to 22 mA.

Known Limitations: None

Glossary

Symbols

Ω

Symbol notation for ohm, a measure of electrical resistance.

µ

Symbol notation for micro (one millionth). For example, µs is the abbreviation for microseconds.

Δ

Symbol notation for delta, the difference between to measurements.

C

channel

A channel is a single input, output, or Sensor Power connection. All I/O Serial Bases, Radio Bases, and Expansion devices have 12 channels. All models feature four universally configurable channels, four input-only channels, and four electrically isolated channels.

E

Expansion Module

Expansion Modules can be added to a Radio Base or Serial Base device to expand the number of I/O channels available. Expansion Modules do not communicate on their own. They require a Radio Base or Serial Base.

K

Kbps

kilo bits per second; 1000 bits per second. For example, 154 kbps.

L

LED

light emitting diode. Located on the side of the Serial Base and Expansion Modules, the LEDs represent power, inbound communication, and outbound communication. For more information, see "I/O Device LEDs" on page 5.

LSB

least significant bit. The bit position that determines whether a number is even or odd.

M

mA

milliAmps. A milliAmp is one thousandth of an amp. For example 100 mA.

megabit

One million bits.

microsecond

One millionth of a second. Abbreviated as µs. For example 5 µs equals 5 millionths of a second.

Mbps

mega bits per second; 1,000,000 bits per second.

ms

milliseconds; one thousandth of a second. For example 5 ms.

Modbus

A serial communications protocol used with programmable logic controllers (PLCs).

P

PLC

programmable logic controller. A digital computer used to automate electro-mechanical processes.

R

Radio Base

A Radio Base provides expandable, wireless I/O. The FGR2-IO-IOE radio is the only Radio Base device available.

register

A single parameter in the Modbus interface for this product. For example, **AI Filter Setting**. Each register available for the Serial Bases and Expansion Modules is described in the"Modbus Register Map" on page 39.

RTU

remote terminal unit. A microprocessor-controlled device that integrates different objects.

S

Serial Base

A Serial Base provides expandable, wired I/O to any device with RS232, RS422, and RS484 data communication interfaces.

SCADA

supervisory control and data acquisition. Computer systems that monitor and control industrial, infrastructure, or facility-based processes.

stack

The Serial Base or Radio base and all Expansion modules attached to it. Up to 15 Expansion Modules can be included in a stack.

T

Tool Suite

A program that provides easy, reliable, and repeatable programming ad monitoring for FreeWave wireless data transceivers, I/O Serial Bases, and Expansion Modules. Tool Suite is available at no cost to you and is available for download from www.freewave.com.

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